2641087

SUPERFUND PROGRAM
RECORD OF DECISION

Crater Resources Superfund Site
Upper Merion Township
Montgomery County, Pennsylvania

SEPTEMBER 2000

DECLARATION

SITE NAME AND LOCATION

The Crater Resources Superfund Site
Upper Merion Township, Montgomery County, Pennsylvania
EPA ID# PAD980419097

STATEMENT OF BASIS AND PURPOSE

This decision document presents the selected remedy for the Crater Resources, Inc./Keystone Coke Company/Alan Wood Steel Company Superfund Site ("Crater Resources" or "Site"), in Upper Merion Township, Montgomery County, Pennsylvania. The remedial action was selected in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 ("CERCLA"), as amended by the Superfund Amendments and Reauthorization Act of 1986 ("SARA"); and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan ("NCP"). The basis for EPA's selected remedy can be found in the Administrative Record for the Site.

The Commonwealth of Pennsylvania has concurred with the selected remedy.

ASSESSMENT OF THE SITE

The response action selected in this Record of Decision is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

DESCRIPTION OF SELECTED REMEDY

The selected remedy described below is the only planned action for the Site. This remedy addresses contaminated soils and sediments, contaminated groundwater, and the waste ammonia liquor ("WAL") pipeline.

The selected remedy includes the following major components:

1) Removal of all contaminated soils and sediment in Quarry 3: Ponds 1, 2, and 3, which are located within Quarry 3, will be dewatered and the water will be transported to an off-site disposal facility. The sediments at the bottom of the ponds will be excavated down to the bedrock layer or to the level where contaminant concentrations in the sediments are at levels protective of groundwater, human health or ecological risk-based concentrations, dewatered, and taken off-site for proper disposal or recycling. The Quarry 3 plateau area will be excavated down to the bedrock layer or to the level where the contaminant concentrations in the soils are at human health or ecological risk-based concentrations, and the soil taken off-site for proper disposal or recycling. All remaining soil areas in Quarry 3 with contaminant levels above human health or ecological risk-based concentrations will be removed and taken off-site for proper disposal or recycling. The excavated areas will then be filled with clean soil to establish a uniform grade, and graded for proper drainage.

2) Construction of a cap to prevent infiltration of surface water into the contaminated soils of Quarries 1, 2 and 4 and other contaminated soil areas: A multi-media cap consisting of a series of low-permeability clays, geotextile liners, sand drainage layers, and soil or other appropriate covers will be installed to prevent unacceptable leaching of contaminants from the soils and sediment into the groundwater. The cap will constructed in accordance with the Commonwealth's Residual Waste Management Regulations, for final cover of Class 1 residual waste landfills, set forth at 25 Pa. Code Sections 288.234 and 288.236-237.

3) Monitored Natural Attenuation of the groundwater: Groundwater monitoring will be conducted at on-site and off-site locations, in order to sample for selected Site-related SVOCs, metals, cyanide, and VOCs that presently exceed preliminary remediation goals. Additional parameters representative of the natural attenuation process will also be included in the monitoring program. This monitoring will provide a basis to determine the rate at which natural attenuation is taking place. EPA has determined that this rate needs to be sufficient to attain the remedial goals within a fifteen (15) year time period. If, during the fifteen (15) year time period, it is evident that the rate of natural attenuation is not sufficient to attain such goals in the fifteen (15) year time frame, EPA will then seek to implement the contingent groundwater remedy, which is described in the "Selected Remedy and Performance Standards" Section of this Record of Decision.

The contingent groundwater remedy calls for groundwater recovery and treatment from the center of the groundwater plume at the Site. The purpose is to extract and treat the most highly contaminated groundwater from beneath the Site. The recovery system would pump the water near the downgradient edges of Quarries 2 and 3 using a line of recovery wells spread across the width of the plume. The groundwater would then be pumped to an on-site treatment facility to remove contaminants to specified treatment levels and the treated water would be discharged to the Schuylkill River or Matsunk Creek.

4) Further investigation of the former WAL pipeline: The pipeline runs from the former Alan Wood Steel facility to Quarries 1, 2, and 3 located on the Site. Some sections of the pipeline been removed by the Crater PRP Group and other private parties during development activities. However, the entire route of the former WAL pipeline will be fully investigated and characterized where there has not been a previous action taken, to determine the existence of any contamination along the route. Any pipeline investigation and clean-up actions which have been conducted in accordance with an EPA accepted risk driven clean-up levels are described in Section II of this ROD. Any pipeline soil areas with contaminant levels above human health or ecological risk-based concentrations will be removed and taken off-site for proper disposal or recycling. In addition, any hardened tar material from past WAL pipeline leaks will be excavated and transported to an off-site disposal facility.

5) Institutional Controls: Institutional controls will be implemented to restrict on-site soil, sediment, surface water and groundwater use and/or disturbance at the Site, except as required for implementation of the remedy, in order to reduce the potential for human exposure to contamination. Institutional controls (e.g., easements and covenants, title notices and land use restrictions through orders from or agreements with EPA) would be established in order to prevent any disturbance of the cap once installed, as well as to preclude the installation of any potable wells in the contaminated aquifer. In addition, institutional controls in connection with adjacent property owners may be required for stormwater management.

STATUTORY DETERMINATIONS

The selected and contingent remedy is protective of human health and the environment, complies with Federal And State requirements that are applicable or relevant and appropriate to the remedial action, is cost effective, and utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable. The selected remedy also satisfies the statutory preference for treatment as a principal element of the remedy (i.e. reduces the toxicity, mobility, or volume of hazardous substances, pollutants, or contaminants as a principal element through treatment).

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure, Pursuant to Section 121(c) of CERCLA, 42 U.S.C. 9621(c), a statutory review by EPA will be conducted no less often than every five years after initiation of the remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment.

ROD DATA CERTIFICATION CHECKLIST

The following information is included in the Decision Summary of this ROD. Additional information can be found in the Administrative Record file for this Site.

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Information	**Location/Page number**
Chemicals of Concern and respective concentrations	Table 2
Baseline risk	Summary of Site Risks / Page16
Cleanup levels and the basis for these levels	Table 12
How source materials constituting principal threats are addressed	Principal Threat Wastes / Page 51
Current and reasonably anticipated future land use and potential future beneficial uses of groundwater	Current and Potential Land and Resource Uses / Pages 15 -16
Potential future groundwater use that will be available at the Site as a result of the Selected Remedy	Current and Potential Land and Resource Uses / Pages 15-16
Estimated capital, annual operation and maintenance, and total present worth costs, discount rate, and the number of years over which the remedy cost estimates are projected	Table 10 and Table 11
Key factors that led to selecting the remedy	Summary of the Rationale for the Selected Remedy / Pages 52 - 53

Abraham Ferdas, Director
Hazardous Site Cleanup Division
EPA Region III

9/27/00
Date

AR306278

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RECORD OF DECISION

CRATER RESOURCES SUPERFUND SITE

PART II - DECISION SUMMARY

I. SITE NAME, LOCATION, AND DESCRIPTION

The Crater Resources Superfund Site ("Site") is located in Upper Merion Township, Montgomery County, Pennsylvania. The National Superfund electronic database identification number is *PAD981035009*. EPA is the lead agency for the Site, with the Pennsylvania Department of Environmental Protection ("PADEP") as the support agency. The Site is currently being addressed through enforcement agreements, with the Potentially Responsible Parties ("PRPs") performing the Remedial Investigation/Feasibility Study ("RI/FS").

The Site covers 50 acres of partially developed land located approximately one mile south of the King of Prussia section of Upper Merion Township, Montgomery County, Pennsylvania (Figure 1). Portions of the Site are currently being developed by private entities. The Site consists of several subdivided parcels, now owned individually by Crater Resources, Inc., Each Parcel As Is, Inc., Out Parcel, Inc., RT Option, Inc., Liberty Property Trust Limited Partnership, and the Gulph Mills Golf Club ("Golf Course"). Four former quarries (Quarries 1, 2, 3, and 4) are located on the Site and cover approximately 14 acres. In addition, two small areas, known as Areas 5 and 6 are on the Site. Portions of the former pipeline which carried the waste ammonia liquor ("WAL") from the former Alan Wood Steel facility to the Site are also in existence. Contamination has been found in the soil, groundwater, and sediment in and beneath Quarries 1, 2, 3, and 4 and Area 6. In addition, contamination has been found in the soils along the route of the former WAL pipeline.

II. SITE HISTORY AND ENFORCEMENT ACTIVITIES

From 1918 until 1977, the Alan Wood Steel Company ("Alan Wood") and its successors operated a coke and coke byproduct manufacturing facility in nearby Swedeland, Pennsylvania. The facility was located on the west side of the Schuylkill River, approximately one mile northeast of the Site. After Alan Wood declared bankruptcy in 1977, the facility and property were first leased and subsequently sold to the Keystone Coke Company ("Keystone Coke"). Keystone Coke produced and sold coke at the facility from 1978 until the spring of 1981, when all operations at the facility ceased.

The coking process typically generated coal gas, light oils, tars containing phenolic compounds, naphthalene (resulting from the destructive distillation of coal), ammonia, and wastewater. WAL was pumped via pipeline from the Alan Wood facility to Quarries 1, 2, and 3, and remnants of the pipeline are still visible near the western edge of Quarry 3. The RI found no evidence that

Quarry 4 was used directly for WAL disposal, but it may have received impacted water as a result of overflows from Quarry 3 and releases from the WAL pipeline.

The Pennsylvania Department of Health ("PADOH") initiated an environmental investigation on January 6, 1969 that was carried through by the Pennsylvania Department of Environmental Resources ("PADER") which lasted throughout the 1970s. PADER, now the Pennsylvania Department of Environmental Protection ("PADEP"), continually asserted into the early 1980s that the use of the quarries was adversely affecting local groundwater. In March 1969, PADOH estimated the levels of phenol in the 43,000 gallons per day ("gpd") of waste being discharged into this quarry at 1,888 parts per million ("ppm"). The sampling documented elevated levels of cyanide, ammonia, and phenol in the WAL discharge and in groundwater in the area. Quarries 1 and 2 were filled in with demolition waste sometime after 1969.

In 1975, Alan Wood installed a prototype treatment plant to treat its industrial wastes and discharge them to the Schuylkill River. However, PADER found that the levels of phenol and cyanides in the plant's effluent exceeded the levels specified in the NPDES permit. On November 26, 1975, Alan Wood signed a Consent Order with PADER, in which Alan Wood agreed to achieve specified effluent limitations for the phenol and cyanides in its discharges before October 31, 1979. Until those limitations were met, Alan Wood was allowed to continue to discharge its effluents to Quarry No. 3. After Alan Wood filed for bankruptcy, discharges to Quarry 3 ceased until Keystone Coke signed a Consent Order with PADER on April 24, 1978, and thereafter reactivated the plant.

During 1977-1979, PADER sampled the WAL discharges to Quarry No. 3, groundwater discharges at neighboring quarries in the region and area wells. PADER reported that sampling showed elevated levels of cyanide, ammonia, and phenol in the WAL discharge and in groundwater in the area during that period of time. In addition, on February 25, 1980, PADER determined that numerous violations of the interim effluent limits had occurred.

On May 16, 1979, EPA conducted a Groundwater Monitoring Survey which involved sampling of Quarry 3 and the surrounding area and included an investigation of possible sources of contamination threatening the Upper Merion Reservoir, a public drinking water source located about one mile to the northwest of the Site and operated by the Philadelphia Suburban Water Company. While conducting sampling at the Site, EPA found phenolic compounds, chlorides, naphthalene, and other organic contaminants in Quarry 3. EPA conducted additional sampling at the Site on May 25, 1979. Subsequently, EPA reported finding trans-1,2-dichloroethylene ("DCE") in both the Upper Merion Reservoir and Quarry 3.

On April 8, 1983, EPA conducted a Preliminary Assessment ("PA") of the Site, followed by a Site Inspection ("SI") on May 9, 1983, during which samples were obtained from Quarry 3 and from three of the monitoring wells that had been installed in 1982 by PADEP in the vicinity of Quarry 3. The PA and SI revealed that hazardous substances were present in Quarry 3 including benzene, toluene, naphthalene, cyanide, zinc, arsenic, lead, phenolic compounds and polynuclear aromatic hydrocarbons ("PAHs"). Analysis of groundwater in the vicinity of the Site, taken from the monitoring wells, showed the presence of benzene and metals including arsenic, cyanide, lead, mercury, zinc, beryllium, nickel, cadmium, and selenium.

In June 1990, EPA took additional samples at the Site. Samples were collected from waste and soil in Quarry 3, ponded water near the quarry, borings of fill material taken from an area believed to be Quarry 1, off-site monitoring and private wells, and the Upper Merion Reservoir. Waste in Quarry 3 contained elevated levels of various contaminants including cyanide, arsenic, benzene, lead, zinc, and PAHs.

The Site was proposed for listing on the National Oil and Hazardous Substances Pollution Contingency Plan National Priorities List ("NPL") of uncontrolled hazardous substances releases pursuant to CERCLA Section 105, 42 U.S.C. § 9605, in February 1992. The Site was listed on the NPL on October 14, 1992.

On September 17, 1994, Beazer East, Inc., Keystone Coke Company, Inc., and Vesper Corporation (herein referred to as the "Crater Resources Participating Parties Group" or "Crater PRP Group") entered into an Administrative Order on Consent ("AOC") with EPA under CERCLA Sections 104 and 122, 42 U.S.C. §§ 9604 and 9622. Under the AOC, the Crater PRP Group agreed to perform a RI/FS at the Site to determine the nature and extent of the contamination at or from the Site, and to evaluate alternatives for remedial action to prevent, mitigate or otherwise respond to or remedy the release or threatened release of hazardous substances, pollutants, or contaminants at or from the Site.

The RI field work was completed in January 1999 and the RI Report was approved by EPA on June 23, 1999. After completion of the RI, the Crater PRP Group commenced the FS to evaluate various remedial alternatives to address the nature and extent of contamination identified in the RI.

In December 1999, EPA completed a Human Health Risk Assessment, which is documented in the Final Baseline Risk Assessment Report, to evaluate the human health risks that could result if no remedial action were taken at the Site. The Final Baseline Risk Assessment Report and RI Report are available for review in the Administrative Record for the Site. The human health risks associated with the Site are discussed in the "Summary of Site Risks" Section of this Record of Decision ("ROD").

On February 29, 2000, a draft FS report was submitted to EPA by the Crater PRP Group. On April 20, 2000, pursuant to Section IX.A.(3) (Submissions Requiring Agency Approval) of the AOC, EPA notified the Crater PRP Group of its intention to modify and subsequently approve the Draft FS Report. EPA has reviewed the Draft FS report and completed an Addendum to the FS Report on June 16, 2000, which is available for review in the Administrative Record for the Site.

Pipeline History

In May 1997, during the RI, an underground section of the WAL pipeline was discovered approximately one mile from the Site, where it crossed beneath Flint Hill Road, before emerging as an aboveground pipeline. This section of pipeline (approximately 30 feet in length) was discovered during the excavation of a stormwater culvert beneath Flint Hill Road. The pipe and adjacent impacted soil (138 tons) were removed and properly disposed off-site. Confirmation sampling indicated that residual soils were below the PADEP Act 2 Statewide Health Medium-Specific Concentrations ("MSCs) for non-residential direct contact with soils and protection of soil-to-groundwater for non-residential soils.

In January 1998, Liberty Property Trust ("Liberty") discovered a second section of underground pipeline on a parcel of land they purchased on and adjacent to the Crater Resources Site. Liberty performed an investigation including surface and subsurface soil sampling to determine the extent of contamination associated with the pipeline. Liberty removed the pipeline sections and associated soils from the property and performed post-excavation sampling and a focused risk assessment. Liberty compared confirmation sampling results to PADEP Act 2 Statewide Health MSCs for non-residential direct contact with soils and protection of soil-to-groundwater for non-residential soils and EPA Risk-Based Concentration Tables and determined that residual soils presented no adverse risk. The work was completed in April 2000.

Additional sections of pipeline have since been removed by the Crater PRP Group. An underground pipeline was found on the property owned by Keystone between Flint Hill Road and River Road, and was removed by the Crater PRP Group and their consultants in December, 1999. The pipeline route on this parcel was approximately 2100 feet in length. Confirmation samples were collected at 150 foot intervals. The investigation, removal and confirmation sampling was performed in accordance with PADEP Act 2 standards. The pipeline and approximately 193.5 tons of soil were removed and properly disposed, and then the excavation was backfilled. Confirmation sampling indicated that residual soils were below the Act 2 Statewide Health MSCs for non-residential direct contact with soils and protection of soil-to-groundwater for non-residential soils.

A 100-foot long portion of the pipeline was also identified in the area of Quarry 1 and Quarry 2 ("O'Neill Parcel"). In July 2000, O'Neill, through their consultant, submitted a work plan to EPA for the removal of the pipeline and soils impacted by WAL.

Area 6 History

In 1997 improvements of Parcel 44 (Area 6) were started. An investigation was conducted to determine subsurface conditions at the lot. Borings advanced in the parcel showed a tarry layer at 20 to 22 feet below ground surface. Samples obtained from this layer showed elevated levels of PAHs and volatile organic compounds ("VOCs"). It was determined that unsuitable soils for development were present; therefore, the owners proceeded with excavation to uncover and remove unsuitable materials. The excavation was 35 feet in depth. Materials were segregated with soils and cinders suitable for backfilling returned to the excavation. Materials geotechnically unsuitable for development where disposed off-site. The tarry materials were tested for RCRA characteristics and disposed as non-hazardous. Confirmation samples taken from the bottom of the excavation and from the remaining materials which were mixed and returned to the excavation were collected and compared to PADEP Act 2 Statewide Health MSCs for non-residential direct contact with soils and protection of soil-to-groundwater for non-residential soils. Results showed levels below the Act 2 standards.

III. HIGHLIGHTS OF COMMUNITY PARTICIPATION

The documents which EPA used to develop, evaluate, and select a remedy for the Site have been maintained at the Upper Merion Township Library, 175 W. Valley Forge Road, King of Prussia, PA and at the EPA Region III Office, Philadelphia, PA.

The Proposed Plan was released to the public on June 16, 2000. The notice of availability for the RI/FS and Proposed Plan was published in the Times Herald on June 16, 2000 and in the King of Prussia Courier on June 22, 2000. A 30-day public comment period began on June 16, 2000 and was initially scheduled to conclude on July 17, 2000. By request, the public comment period was extended until August 15, 2000. The notice to extend the comment period was published in the Times Herald and the King of Prussia Courier on July 6, 2000.

A public meeting was held during the public comment period on June 27, 2000. At the meeting, representatives from EPA answered questions about the Site and the remedial alternatives under consideration. Approximately 50 people attended the meeting, including residents from the impacted area, potentially responsible parties, and news media representatives. A summary of comments received during the comment period and EPA's responses are contained in Part III of this document.

EPA finalized a Community Relations Plan ("CRP") for the Site in July, 2000. This is the first CRP developed for the Site, and identifies issues of community concern and interest related to the Site. The CRP contains information that EPA used in conducting interviews, and assesses past community involvement efforts at the Site. The CRP also identifies the actions which EPA will continue to take to facilitate community participation during the actual clean-up of the Site.

EPA has met with the various stakeholder groups to identify the anticipated future land use. EPA has met with the current landowners, their counsel, and technical consultants numerous times in order to obtain an understanding of the anticipated future land use, which are discussed in the "Current and Potential Future Land and Resource Uses" section of this ROD. EPA has also met with the Upper Merion Township officials and the Environmental Advisory Council to provide an overview of the Site and the pending actions, as well as to obtain input concerning the

Township's concerns with the future development of this property. EPA also met with and interviewed nearby residents to obtain their input concerning the future uses of the property.

The actions discussed above fulfill the public notification requirements of Sections 113(k)(2)(B), 117(a), and 121(f)(1)(G) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended ("CERCLA"), 42 U.S.C. §§ 9613(k)(2)(B), 9617(a), and 9621(f)(1)(G) (also known as "Superfund") and the general requirements of the National Oil and Hazardous Substances Contingency Plan ("NCP"), 40 CFR Section 300.430(f)(2).

IV. SCOPE AND ROLE OF RESPONSE ACTIONS

This final selected remedy addresses the threats posed by the release of hazardous substances at the Site. The primary objective of the remedy described in this ROD is to reduce or eliminate the potential for human and ecological exposure to contamination at the Site. The selected remedy will comprehensively address the risks posed by the release or threat of release of hazardous substances from the Site.

The Site covers 50 acres of partially developed land located approximately one mile south of the King of Prussia section of Upper Merion Township, Montgomery County, Pennsylvania. Four former quarries (Quarries 1, 2, 3, and 4) are located on the Site and cover approximately 14 acres. In addition, two small areas, known as Areas 5 and 6 are on the Site. Portions of the former pipeline which carried the WAL from the former Alan Wood Steel facility to the Site are also in existence. Contamination has been found in the soil, groundwater, and sediment in and beneath Quarries 1, 2, 3, and 4 and Area 6. In addition, contamination has been found in the soils along the route of the former WAL pipeline.

The major components of the selected remedy include:

1) Removal of all contaminated soils and sediment in Quarry 3: Ponds 1, 2, and 3, which are located within Quarry 3, will be dewatered and the water will be transported to an off-site disposal facility. The sediments at the bottom of the ponds will be excavated down to the bedrock layer or to the level where contaminant concentrations in the sediments are at levels protective of groundwater, human health or ecological risk-based concentrations, dewatered, and taken off-site for proper disposal or recycling. The Quarry 3 plateau area will be excavated down to the bedrock layer or to the level where the contaminant concentrations in the soils are at human health or ecological risk-based concentrations, and the soil taken off-site for proper disposal or recycling. All remaining soil areas in Quarry 3 with contaminant levels above human health or ecological risk-based concentrations will be removed and taken off-site for proper disposal or recycling. The excavated areas will then be filled with clean soil to establish a uniform grade, and graded for proper drainage.

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The contingent groundwater remedy calls for groundwater recovery and treatment from the center of the groundwater plume at the Site. The purpose is to extract and treat the most highly contaminated groundwater from beneath the Site. The recovery system would pump the water near the downgradient edges of Quarries 2 and 3 using a line of recovery wells spread across the width of the plume. The groundwater would then be pumped to an on-site treatment facility to remove contaminants to specified treatment levels and the treated water would be discharged to the Schuylkill River or Matsunk Creek.

4) Further investigation of the former WAL pipeline: The pipeline runs from the former Alan Wood Steel facility to Quarries 1, 2, and 3 located on the Site. Some sections of the pipeline been removed by the Crater PRP Group and other private parties during development activities. However, the entire route of the former WAL pipeline will be fully investigated and characterized where there has not been a previous action taken, to determine the existence of any contamination along the route. Any pipeline investigation and clean-up actions which have been conducted in accordance with an EPA accepted risk driven clean-up levels are described in Section II of this ROD. Any pipeline soil areas with contaminant levels above human health or ecological risk-based concentrations will be removed and taken off-site for proper disposal or recycling. In addition, any hardened tar material from past WAL pipeline leaks will be excavated and transported to an off-site disposal facility.

5) Institutional Controls: Institutional controls will be implemented to restrict on-site soil, sediment, surface water and groundwater use and/or disturbance at the Site, except as required for implementation of the remedy, in order to reduce the potential for human exposure to contamination. Institutional controls (e.g., easements and covenants, title notices and land use restrictions through orders from or agreements with EPA) would be established in order to prevent any disturbance of the cap once installed, as well as to preclude the installation of any potable wells in the contaminated aquifer. In addition, institutional controls in connection with adjacent property owners may be required for stormwater management.

V. SUMMARY OF SITE CHARACTERISTICS

The 50-acre Crater Resources Site, located in Upper Merion Township, Pennsylvania, contains four former quarries that cover approximately 14 total acres (Figures 1 and 2). Three of the quarries were backfilled to grade and one quarry (Quarry 3) was left open. Quarry 3 is approximately 8 acres in size with a depth of 65 feet.

The climate of the area is moderate with average annual temperatures of 54° F and monthly average ranges from 33° F in February to 77° F in July. Average annual rainfall in Montgomery County, Pennsylvania ranges from 42 to 47 inches per year.

Regional Geology

The Crater Resources Site is located in the eastern portion of the Piedmont Physiographic province. Typical characteristics of the Piedmont are undulating topography with east-northeast trending ridges underlain by crystalline bedrock. Low-lying valley areas in the Piedmont are typically underlain by less-resistant sedimentary and metasedimentary rock. Regionally, the Site is in the eastern end of the east-northeastward trending Chester Valley geologic province. The Chester Valley province extends approximately 50 miles through Montgomery, Chester, and Lancaster Counties and ranges from 1 to 2.5 miles in width. This province consists of steeply-dipping, folded and faulted Cambrian to Ordovician age carbonate bedrock consisting of three formations. From oldest to youngest, these formations are the Cambrian Ledger Formation, the Elbrook Formation, and the Ordovician Conestoga Formation.

The Cambrian Ledger Formation is composed of massively-bedded, coarsely-crystalline dolomite, with an estimated thickness of approximately 600 feet. The Elbrook Formation is up to 300 feet thick, and consists of thinly-bedded, argillaceous and sandy, siliceous limestone, with some interbedded dolomite and marble. The Conestoga Formation is up to 500 feet thick in the Upper Merion area of the Chester Valley. It consists of impure, thinly-bedded, micaceous and graphitic limestone and marble, with shale partings. On the south side of the Chester Valley where the Site is situated, the carbonates have been metamorphosed to siliceous and micaceous marbles. The Site is underlain by the Conestoga Formation, which was mined in Quarry 3 (Figure 3). The bedrock strike of the carbonates in the Upper Merion area ranges from approximately north 75 degrees east (N75E) to north 85 degrees east (N85W). Strata dip to the south, with dip angles ranging from approximately 45 degrees in the northern part of the Valley, to 60 to 70 degrees near the Site. The bedrock in the Site vicinity is extensively fractured and jointed.

Studies of the joint patterns at the Site indicate a set of joints that trends N50-60E and a set that trends N10-20E). Other less developed joint sets trend northwest-southeast and north-south. Two regional principal fracture trace alignments in the Upper Merion Township have been identified; one trending west/northwest and one trending north/northeast, in addition to a minor east-west alignment. Surficial evidence, including outcrops and road and quarry cuts in the Chester Valley area, indicate that surficial karst features such as sinkholes and pinnacle weathering have developed in the carbonate bedrock. These surficial features suggest that there has likely also been extensive subsurface development of karst dissolution features. Subsurface solution features are likely to develop along pre-existing bedrock discontinuities such as along bedding plane, fractures, and joint systems. Studies of sinkhole development in the Upper Merion area indicate that the most consistent trend, based on sinkhole distribution, is parallel to bedrock strike. In relation to the Site, this trend would indicate that the dominant pathways available for groundwater flow are to the East-Northeast and to the North-Northeast.

To the north of the Site, the carbonates are unconformably overlain by the younger Triassic-age Stockton Formation or the Cambrian-age Antietam and Harpers Formations. The Triassic rocks are characterized by red, brown, and gray sandstone, siltstone, and shale. The Cambrian rocks are characterized by gray quartzite and phyllite. To the south of the Site, the carbonates are bordered by schist and phyllite of the Wissahickon Formation. The contact between the two rock types is marked by the Martic Fault Line, which is actually a zone of tectonic transition between the two geologic provinces. The Martic Line is considered by many researchers to be a zone of complex geologic structure in which the older metamorphic rocks to the south were thrust-faulted and overlie the younger carbonates to the north. This thrust faulting has resulted in a series of secondary off-shoot faults or splay faults whereby sheets of metamorphic schists and gneiss are incorporated in an imbricated (inclined stack) fashion between sheets of sedimentary carbonates. A unit of thrust faulted schist has been identified by drilling and seismic surveys underlying part of the Site.

Regional Hydrogeology

The groundwater flow direction in the Chester Valley carbonate aquifers is expected to be controlled primarily by hydraulic gradient, and the orientation of bedding plane fractures and joints in the bedrock. In addition, the density, interconnection, and aperture size of the bedding planes and bedrock fractures play an important role in determining the aquifer productivity. Karst dissolution features that tend to form preferentially along fractures, bedding planes, and other weak zones in the carbonates can potentially increase the aquifer transmissivity in preferred directions.

Based on an interpretation of the bedrock geology, the predominant groundwater flow direction in the Site vicinity is expected to be to the east/northeast toward the Schuylkill River, which is parallel to bedrock strike. However, groundwater in the vicinity of the Site may also have a smaller, northeast component of flow, due to the presence of north/northeast-trending bedrock fractures, and large volume pumping to the north.

An average of 10 million gallons per day ("MGD") of groundwater is pumped from the Upper Merion Reservoir ("UMR"). In addition, groundwater is also pumped from the McCoy Quarry, which is located approximately one mile northeast of the Site. Previous studies considered the effects of pumping at the UMR and McCoy Quarry and concluded that the combined pumping at the two locations have created overlapping elongate cones of depression oriented approximately N60E parallel to bedrock strike. As a result of this cone of depression, hydraulic gradients are steeper in the north-south direction than east-west. This suggests high transmissivity and high flow rates along strike, and low transmissivity and low flow rates perpendicular to strike. The southern limit of this cone of depression extends to the area of the Site. It has not been proven whether the Site lies within this cone of depression.

Site Soils

The soils in the Site vicinity were mapped by the United States Soil Conservation Service as the Beltsville silt loam. These soils are classified as deep, moderately well-drained to somewhat poorly-drained, gently-sloping soils that form from silt, clay, sand and gravel. The soil has a low permeability layer in the subsoil which impedes downward movement of water. As a result, soils of this association typically exhibit a seasonal high water table.

The bedrock in the Site vicinity is overlain in some areas by unconsolidated, Cenozoic-age sand and gravel deposits. The unconsolidated deposits near the Site are mapped as the Tertiary-age Pennsauken and Bridgeton Formations (undifferentiated). Quarries 1,2, and 4 were likely excavated in this formation.

Hydrology

Surface water drainage in the Site vicinity is generally eastward toward the Schuylkill River located approximately 1 mile from the Site. The area southeast of the Site is drained by Matsunk Creek which discharges to the Schuylkill River. Surface water present on the Site primarily consists of ponded water contained within Quarry 3.

Land Use

The Site covers 50 acres of partially developed land located approximately one mile south of the King of Prussia section of Upper Merion Township, Montgomery County, Pennsylvania. Portions of the Site are currently being developed by private entities. Four former quarries (Quarries 1, 2, 3, and 4) are located on the Site and cover approximately 14 acres. In addition, two small areas, known as Areas 5 and 6 are on the Site. Portions of the former pipeline which carried the WAL from the former Alan Wood Steel facility are also in existence.

Land use surrounding the Site is primarily suburban commercial/industrial and consists of a mix of light industrial, commercial, and scattered residential use.

Conceptual Site Model

Soils and sediments in the quarries and soils impacted by releases from the WAL pipeline were contaminated by discharges of WAL. The contamination associated with the soils may be transported by various mechanisms and exposure routes to human and biotic receptors.

Future residents, current and future trespassers, and future industrial, and construction workers may be subject to exposure to contaminants in soil via direct contact. Potential exposures are via ingestion and/or dermal contact. Should contaminants become airborne either by wind erosion or construction activities, inhalation becomes a potential exposure route. Terrestrial biota are also subject to exposure via dermal exposure and ingestion of contaminated soils as well as via inhalation of airborne materials.

Groundwater has also been impacted at the Site by infiltration/percolation of contaminants from the soil into the aquifer. Potential exposure scenarios include future residents and industrial workers via ingestion, dermal contact, and, in the case of VOCs, via inhalation. Table 1 presents all the routes of exposure, potential pathways, and receptors evaluated.

Nature and Extent of Contamination

During the RI, surface and subsurface soil samples were collected from each of the four quarries and surface water and sediment samples were collected from Quarry 3. In addition, monitoring wells were installed and sampled and other off-site wells were also sampled to evaluate groundwater quality and impacts both on- and off-site. Figures 4 through 8 present the sampling locations. Other potential areas of concern were also investigated. Samples were analyzed for target compound list ("TCL") VOCs, semivololatile organic compounds ("SVOCs"), pesticides/polychlorinated biphenyls ("PCBs"), and target analyte list ("TAL") metals and cyanide. A brief description of the number and types of samples at each area, as well as a summary of results are presented below. A detailed discussion of results by media follows and significant chemicals of concern may be found as part of Table 2. Table 2 shows the risk drivers, or chemicals of concern ("COCs"), which require action. These are different from chemicals of potential concern ("COPCs"), which are the chemicals that the risk assessor looks at to see whether they are ultimately hazardous enough to become COCs.

Quarry 1

During the Remedial Investigation, seven subsurface soil and five surface soil samples were taken in Quarry 1. Sludge-like material was encountered in the northeastern portion of the quarry at a depth of 19 feet, and a zone of stained silty clay was encountered at a depth of 71 feet in the central portion of the quarry. These materials contained elevated concentrations of VOCs, cyanide, and PAHs. Elevated levels of metals were also noted at depths between six and eight feet.

Quarry 2

Five surface soil and six subsurface soil samples were taken in Quarry 2. A layer of stained soil was observed starting eight feet below the surface and extending to depths of 23 feet. PAHs were detected in all of the soil samples collected from Quarry 2. Elevated levels of metals and cyanide were found in the stained material, and in the sand at a depth of 50 to 52 feet.

Quarry 3

Four surface soil samples and nine subsurface soil samples were collected within Quarry 3. Sample results showed elevated levels of phenols and several PAHs. High levels of several metals were found in all soil samples taken in the quarry.

Five surface water samples and fourteen sediment samples were collected from the ponds in Quarry 3. Sediment samples were collected by cores to evaluate the constituents contained in the entire sediment layer. Pond 1 sediments are between 10 and 16 feet thick; Pond 2 sediments vary from 0.5 to 5 feet thick; and Pond 3 contains 3 to 7 feet of sediments. Results show surface water with low levels of several metals and cyanide. The sediments in the bottom of the three ponds in Quarry 3 are tarry in nature and contain elevated concentrations of PAHs. The Quarry 3 surface water had no unacceptable risk, and therefore there is no Table 2 for surface water.

Quarry 4

Two surface soil samples and four subsurface soil samples were collected from Quarry 4. The soils in Quarry 4 contain concentrations of PAHs, cyanide, pesticides, and metals.

Other Surface Soil ("SS") Samples

SS-1 and SS-2 were collected in the areas where the pipeline valves were located. These samples contained concentrations of PAHs and metals, indicating that the pipeline leaked in this area. Sample SS-3 was taken in a swale east of Quarry 3 and contained phenols, PAHs, and several metals.

Pipeline

Soil samples that were collected adjacent to and beneath a portion of the buried pipeline, which has since been removed, indicated the presence of several PAHs and metals.

Area 5

One soil sample was taken from Area 5 and indicated low concentrations of PAHs and cyanide in the surface soils, but did not contain any volatile organic compounds (VOCs). Soil at 30 to 32 feet below ground surface contained low concentrations of VOCs and metals. Area 5 had no unacceptable Site-related risk, and therefore has no Table 2.

Area 6

A small lens of tarry material was found in a soil boring during a sampling event conducted by Pennoni Associates Inc. in 1993. The tarry material contained elevated VOCs (e.g., benzene up to 2,100 ug/kg) and several PAHs, including naphthalene (up to 29,000,000 ug/kg). Soil and materials in Area 6, determined to be geotechnically unstable during an investigation by the current property owner, were recently removed by a private contractor so the property could be marketed for development. The new surface cover for Area 6 is below levels of concern for industrial workers. Residential exposure was not assessed, and construction worker exposure below the cap could result in a Hazard Index ("HI") above 1.

Surface Soils

Elevated levels of PAHs, metals, and cyanide were detected in surface soils throughout the Site. The highest levels of contaminants detected in surface soils were detected in the quarries, particularly in Quarry 3; however, elevated levels of contaminants were also detected in surface soils from the other quarries and from the drainage swale east of Quarry 3. Low levels of PAHs and cyanide were also detected in surface soils from Area 5. The highest levels of these contaminants were detected in Quarry 3. Contaminants typically detected in surface soils include, but are not limited to, aluminum (up to 26,700 mg/kg), arsenic (up to 302 mg/kg), cyanide (up to 175 mg/kg), iron (up to 52,500 mg/kg), manganese (up to 1,940 mg/kg), benzo(b)fluoranthene (up to 630,000 ug/kg), benz(a)pyrene (up to 460,000 ug/kg), dibenzofuran (up to 19,000 ug/kg), naphthalene (500,000 ug/kg), and phenol (4,400 ug/kg).

Subsurface Soils

PAHs and metals were detected in subsurface soils throughout the Site. Subsurface soils in Quarry 1 showed elevated PAHs, VOCs, and metals in the majority of samples with the highest levels of metals (aluminum, 30,500 mg/kg; manganese, 2,480 mg/kg) at depths from 6 to 8 feet. The samples collected from 19 to 20 feet contained the highest levels of VOCs (e.g., benzene, 7,400 ug/kg; ethylbenzene, 21,000 ug/kg; toluene, 48,000 ug/kg; total xylenes, 170,000 ug/kg) and PAHs (e.g., naphthalene, 3,100,000 ug/kg; dibenzofuran, 41,000 ug/kg; phenanthrene, 150,000 ug/kg; pyrene, 38,000 ug/kg; benzo(a)pyrene, 31,000 ug/kg) detected in Quarry 1. Elevated levels of arsenic (up to 69.5 mg/kg) were also detected at these depths. Lower, but elevated, levels of these contaminants were detected in the stained materials at a depth of 71 feet in this quarry.

A layer of stained soil was observed starting eight feet below the surface of Quarry 2 and extending to depths of 23 feet. Several PAHs were detected in all of the soil samples collected from Quarry 2. Minor concentrations of cyanide were found in the stained material, and in the sand at a depth of 50 to 52 feet. Several elevated levels of metals were present, including iron (up to 143,000 mg/kg) and manganese (up to 1530 mg/kg).

Subsurface soils, collected up to depths of 12 feet within Quarry 3, showed elevated levels of VOCs, phenols, PAHs, and metals. The contaminants include the following: benzene (up to 11,000 ug/kg), toluene (up to 110,000 ug/kg), styrene (up to 62,000 ug/kg), total xylenes (up to 260,000 ug/kg), phenol (up to 770,000 ug/kg), benzo(a)anthracene up to 680,000 ug/kg; benzo(b)fluoranthene up to 690,000 ug/kg; benzo(a)pyrene up to 470,000 ug/kg; dibenz(a,h)anthracene up to 100,000 ug/kg; 2-methylnaphthalene up to 3,500,000 ug/kg; indeno(1,2,3-cd)pyrene up to 330,000 ug/kg; and naphthalene up to 270,000,000 ug/kg. High levels of aluminum (up to 26,700 mg/kg), cyanide (927 mg/kg), iron (up to 62,000 mg/kg), mercury (up to 49 mg/kg), arsenic (up to 660 mg/kg) and manganese (up to 1,140 mg/kg) were also present in the subsurface soils in Quarry 3.

The subsurface soils in Quarry 4 contain elevated levels metals, cyanide, VOCs, and low levels of pesticides. Several metals including aluminum (up to 22,600 mg/kg), iron (up to 113,100 mg/kg), manganese (up to 6,200 mg/kg), and vanadium (up to 2140 mg/kg) are present in Quarry 4. Cyanide (up to 17.4 mg/kg) levels were greatest at depths of 6 to 8 feet. The highest levels of VOCs were detected from 18 to 20 feet and include acetone (530 ug/kg), TCE (66 ug/kg) and PCE (59 ug/kg).

Subsurface soils collected in Area 5 at depths of 30 to 32 feet below ground surface contained low concentrations of carbon disulfide at 10 ug/kg, 2-butanone at 24 ug/kg, and bis (2-ethylhexyl) phthalate at 88 ug/kg. Some low levels of metals were detected in this sample, including aluminum at 2,520 mg/kg.

The subsurface soils collected in Area 6 at depths of 20 to 22 feet include benzo(a)anthracene up to 8,800mg/kg; benzo(b)fluoranthene up to 5,700 mg/kg; benzo(a)pyrene up to 8,100 mg/kg; dibenz(a,h)anthracene up to 1,600 mg/kg; indeno(1,2,3-cd)pyrene up to 4,600 mg/kg; and arsenic up to 13.8 mg/kg.

Surface Water

Surface water is found in the three ponds in Quarry 3. The surface water contains low levels of cyanide (up to 1,940 ug/L), iron (up to 989 ug/L for dissolved metals analyses), mercury (up to 0.29 ug/L), and selenium (up to 30.8 ug/L for dissolved metals analyses).

Sediment

The sediments in the bottom of the three ponds in Quarry 3 are tarry in nature and contain elevated concentrations of PAHs, VOCs, metals, and cyanide. Elevated PAHs include benzo(a)anthracene ranging from 14 to 2100 mg/kg; benzo(b)fluoranthene ranging from 28 to 3800 mg/kg; benzo(a)pyrene ranging from 16 to 2500 mg/kg; and naphthalene ranging from 27 to 37,000 mg/kg. Phenol was detected at levels up to 1,600 mg/kg. VOCs detected include benzene (up to 45,000 ug/kg), toluene (up to 84,000 ug/kg), styrene (up to 91,000 ug/kg) and xylene (up to280,000 ug/kg). Cyanide was detected at levels up to 5,280 mg/kg. Other inorganics include arsenic (up to 266 mg/kg), iron (up to 50,200 mg/kg), and mercury (up to 28.7 mg/kg).

Groundwater

One round of groundwater samples was taken during the Remedial Investigation, between 1996-1998. A total of 17 monitoring wells and 16 off-site wells were sampled. The sampling indicated that the groundwater plume extends from Quarry 1, toward the northeast. Groundwater data collected during the RI concluded that groundwater flows primarily to the east/northeast, in the direction of the Schuylkill River.

In general, elevated levels of VOCs, SVOCs, and cyanide in the groundwater were found near the source of the quarries on-site. VOCs detected included acetone up to 420 micrograms per liter (ug/L), benzene up to 250 ug/L, and chloroform up to 3.9 ug/L. SVOCs detected include naphthalene up to 1300 ug/L, dibenzofuran up to 16 ug/L, 2,4-dimethylphenol up to 580 ug/L, 2-methylphenol up to 6300 ug/L, 4-methylphenol up to 24,000 ug/L, and phenol up to 19,000 ug/L. Cyanide was detected at levels up to 1,120 ug/L. As discussed in the RI, napthalene, phenols, and cyanide are among the most mobile Site-related contaminants.

The monitoring wells located directly downgradient of each of the quarries tended to have high concentrations of metals including arsenic (up to 49.85 ug/L), beryllium (up to 245 ug/L), chromium (up to 205 ug/L), and manganese (up to 33,600 ug/L). The metals concentrations were highest at the northeastern end of the Site.

Low concentrations of Site-related constituents were detected in the monitoring wells that reach the outer edges of the groundwater plume. Some chlorinated VOCs were detected at low concentrations in the golf course well and the pond well. Low concentrations of phthalates were also detected in several of the wells across Renaissance Boulevard owned by Liberty. Chlorinated VOCs were detected in several of the wells sampled on the SmithKline Beecham property located approximately 0.5 miles east of the Site.

VI. CURRENT AND POTENTIAL FUTURE LAND AND RESOURCE USES

The Site is located on several subdivided parcels, now owned individually by Crater Resources, Inc., Each Parcel Asis, Inc., Out Parcel, Inc., RT Option, Inc., RAGM Settlement Corporation, Liberty Property Trust, Inc. and its affiliates ("Liberty"), and Gulph Mills Golf Club ("Golf

Course"). The Site was placed on the CERCLA National Priorities List ("NPL") on October 14, 1992.

Site development by Liberty has already commenced and more development is anticipated by future landowners on the remaining parcels. Liberty has advised EPA of its intention to construct another office building on the property Liberty owns at the Site. In addition, O'Neill Properties Group, L.P. ('O'Neill") is contemplating the purchase of several parcels at the Site for the purpose of constructing office buildings.

The lands owned by Crater Resources, Inc., Each Parcel Asis, Inc., Out Parcel, Inc., RT Option, Inc., RAGM Settlement Corporation, and Liberty all fall within Renaissance Park (a commercial office park) and are subject to perpetual deed restrictions which limit the use of the lands to commercial and light industrial use. Residential use would only be permitted if (1) an owner of at least 20 contiguous acres sought to develop a mixed-use development, and (2) Swedeland Road Corporation specifically approved such a use. The lands that might even qualify for a special application for residential use are now under construction for nonresidential, commercial uses or under agreements of sale for such nonresidential uses. The remaining property owner, Gulph Mills Golf Club, has agreed in principle to covenants that prevent residential development or potable water well installation on the affected portion of its property; these covenants are presently awaiting finalization. Therefore, as a practical matter, residential use will be prohibited by the deed covenants.

The RI has determined that there is no private well water use for potable supply within the area potentially affected by the Site. Furthermore, Upper Merion Township requires that all residential, commercial, and industrial potable water users connect to public water if there is a public water main on their street. Water wells for non-potable use are permitted. Surface water drainage in the Site vicinity is generally eastward towards the Schuylkill River, which is a mile east of the Site. Matsunk Creek drains the area southeast of the Site, including the golf course, and discharges to the Schuylkill River. It is anticipated that the Renaissance Pond well will continue to be used for office park irrigation purposes. The UMR is located within a mile of the Site.

VII. SUMMARY OF SITE RISKS

Based on the results of the RI, EPA conducted analyses to estimate the human health and environmental hazards that could result if no remedial action were taken at the Site. The purpose of the risk assessment is to establish the degree of risk or hazard posed by contaminants at the Site, and to describe the routes by which humans or environmental receptors could come into contact with these contaminants. Risk is a function of both toxicity and exposure. The results of the risk assessment are used to determine if remediation is necessary, to help provide justification for performing the remedial action, and to assist in determining which exposure pathways need to be rededicated. The conceptual site model discussed in Section V of this ROD identifies the potential exposure pathways and receptors.

A. Human Health Risks

The baseline human health risk assessment provides the basis for taking action and identifies the contaminants and exposure pathways that need to be addressed by the remedial action. This section of the ROD summarizes the baseline risk assessment for the Site.

Identification of Potential Contaminants of Concern

Contaminants of concern ("COCs") for each medium and exposure pathways were selected based on a variety of criteria. COCs are selected based on both their carcinogenic and non-carcinogenic toxicity. The human health risk assessment in the administrative record provides details of the process and contribution to toxicity values for all contaminants detected; however, for this ROD, only the most significant COCs (i.e., contaminants significantly greater than background that contribute to total cancer risks greater than 1E-04 or a non-cancer hazard index greater than 1) are presented. Table 4 provides risks by COCs for each significant receptor and Table 5 presents total risks to individual receptors by medium.

The most significant COCs detected for each medium, and the range of concentrations, are presented in Table 2. The RI presents concentration ranges for all compounds. For groundwater, COCs include several metals and cyanide, PAHs and VOCs. Metals, cyanide, and PAHs were detected in surface and subsurface soils and sediments throughout the Site including the quarries and soils associated with the WAL pipeline. Table 1-1 of the FS (as amended by EPA comments) lists the COCs for each area of concern.

The data quality was also evaluated for use in the risk assessment. In general, sampling technique, analytical methods, sampling locations, etc. were appropriate for the evaluation. For groundwater, due to low yields in several wells, samples were obtained by hand bailers which could, in theory, reduce the levels of VOCs and increase the levels of total metals in the samples due to agitation of the water column.

Exposure point concentrations ("EPCs") were calculated for each of the COCs to determine a representative concentration to evaluate risks. EPCs are based either on reasonable maximum exposure ("RME") or central tendency exposure ("CTE"). RME is the exposure that is expected to represent a high-end exposure in a medium or area of interest. RME EPCs are selected from the maximum value, the 95% upper confidence limit on the mean of normally distributed data ("95% UCL-N"), or the 95% upper confidence limit on log transformed data ("95% UCL-T"). The UCL for the appropriate distribution is preferred. If, however, this value exceeds the maximum, then the maximum concentration is used as the EPC. CTE is the exposure that is expected to represent an average exposure to a given medium or area. For this evaluation, the more conservative RME values have been used. EPCs and statistical measures used to determine EPCs for each of the significant COCs may be found in Table 2. EPCs for all COCs may be found in the baseline risk assessment.

Exposure Assessment

Risks posed to various exposure pathways, media, and receptors by Site contaminants were evaluated. Table 1 and the conceptual Site model discussed earlier present these scenarios. The baseline risk assessment presents risks for all these scenarios. This ROD presents information on the risks for the most significant chemicals of concern ("COCs") and receptors at the greatest risk. In general, receptors at greatest risk include future potential residential receptors, particularly children exposed to groundwater (via ingestion, dermal contact, and inhalation of vapors during showering) and surface soils (via ingestion, dermal contact, and inhalation of particulates and/or volatilized vapors), future industrial workers exposed to surface soils (via ingestion, dermal contact, and inhalation of particulates and/or volatilized vapors), and future construction workers exposed to surface and subsurface soils (via ingestion, dermal contact, and inhalation of particulates and/or volatilized vapors). Table 2 presents the COCs and exposure point concentration ("EPC") for each of the significant COCs detected in various Site media (i.e., surface soils, subsurface soils, groundwater, surface water, and sediment). The EPC is the concentration that was used to estimate the exposure and risk from each COC. The table includes the range of concentrations detected for each COC as well as the frequency of detection (i.e., the number of times the COC was detected in a particular medium and the number of samples collected for that medium), the EPC, and the statistical measure used to determine the EPC.

Toxicity Assessment

The toxicity assessment weighs available evidence regarding the potential for a particular contaminant to cause adverse effects in exposed individuals. Where possible, the assessment provides a quantitative estimate of the relationship between the extent of exposure to a contaminant and the increased likelihood or severity of adverse effects. The toxicity assessment includes hazard identification and information to determine if exposure to a contaminant can cause an increase in the incidence of an adverse health effect (carcinogenic and non-carcinogenic) and a dose-response evaluation to quantify the relationship between the exposure of the contaminant at the levels present to increased incidence of adverse effects.

Various toxicity values, such as reference dose and cancer slope factors, are derived to estimate the potential for adverse effects of exposure in humans. These values are used in the risk characterization. Toxicity information is available from several databases including the Integrated Risk Information System ("IRIS"), Health Effects Summary Tables ("HEAST"), or provisional values from the Superfund Technical Support Center. Table 3 presents toxicity values and affected target organs for the COCs selected in Table 2.

Human Health Effects

Potential adverse human health effects for all Site COCs are presented in Appendix A; Toxicological Profiles.

Risk Characterization

Risk characterization summarizes and combines the results of the toxicity and exposure assessments to characterize risks both quantitatively and qualitatively.

For carcinogens, risks are generally expressed as the incremental probability of an individual's developing cancer over a lifetime as a result of exposure to the carcinogen. Excess lifetime cancer risk is calculated from the following equation:

Risk = CDI x SF

where: risk = a unitless probability (e.g., 2×10^{-5}) of an individual's developing cancer
CDI = chronic daily intake averaged over 70 years (mg/kg-day)
SF = slope factor, expressed as $(\text{mg/kg-day})^{-1}$.

These risks are probabilities that usually are expressed in scientific notation (e.g., 1×10^{-6} or 1E-06). An excess lifetime cancer risk of 1×10^{-6} indicates that an individual experiencing the reasonable maximum exposure estimate has a 1 in 1,000,000 chance of developing cancer as a result of Site-related exposure. This is referred to as an "excess lifetime cancer risk" because it would be in addition to the risks of cancer individuals face from other causes such as smoking or exposure to too much sun. The chance of an individual's developing cancer from all other causes has been estimated to be as high as one in three. EPA's generally acceptable risk range for Site-related exposures is 10^{-4} to 10^{-6}.

The potential for noncarcinogenic effects is evaluated by comparing an exposure level over a specified time period (e.g., life-time) with a reference dose ("RfD") derived for a similar exposure period. An RfD represents a level that an individual may be exposed to that is not expected to cause any deleterious effect. The ratio of exposure to toxicity is called a hazard quotient ("HQ"). An HQ<1 indicates that a receptor's dose of a single contaminant is less than the RfD, and that toxic noncarcinogenic effects from that chemical are unlikely. The Hazard Index ("HI") is generated by adding the HQs for all chemical(s) of concern that affect the same target organ (e.g., liver) or that act through the same mechanism of action within a medium or across all media to which a given individual may reasonably be exposed. An HI<1 indicates that, based on the sum of all HQ's from different contaminants and exposure routes, toxic noncarcinogenic effects from all contaminants are unlikely. An HI > 1 indicates that Site-related exposures may present a risk to human health. Above 1, toxic effects do not necessarily occur, but can no longer be ruled out.

The HQ is calculated as follows:

Non-cancer HQ = CDI/RfD

where:

CDI = Chronic daily intake
RfD = reference dose.

CDI and RfD are expressed in the same units and represent the same exposure period (i.e., chronic, subchronic, or short-term).

Table 4 presents quantified carcinogenic and non-carcinogenic risks for each COC for each major exposure pathway. Table 4 also presents HI for individual target organs. The scenarios presenting the most significant risks included in Table 4, are future residential child exposed to groundwater (center of plume) with surface soils from Quarries 1, 2, and 4, and surface soil, surface water, and sediment from Quarry 3; construction worker exposure to total soils in Quarries 1, 2, 3 and Area 6; and current industrial worker to groundwater (center of plume) and surface soils from Quarry 4.

Table 5 presents a summary of the significant Site-related (HI > 1, cancer risk > 1E-4) carcinogenic and non-carcinogenic risks for each potential receptor for each source area/medium at the Site for all COCs. A discussion of the risks for each source area/medium follows.

<u>Groundwater</u>

Exposure to groundwater from the center of the plume, and extent of plume, would result in increased cancer risk to the future residential child, future residential adult, industrial worker and lifetime resident. The greatest risk is to the future resident with increased cancer risks of 1.0E-03 (center of plume), and 8.0E-04 (extent of plume). The increased potential for non-carcinogenic effects is reflected in Hazard Index values of 550 for the center of the plume, and 160 for the extent of the plume. Increased carcinogenic risks are primarily due to arsenic, while the non-carcinogenic risks are due to metals, particularly manganese, and phenols, PAHs and VOCs, particularly benzene. Ingestion of groundwater is the most significant exposure pathway (Tables 4 and 5).

<u>Quarry 1</u>

Levels of COCs present in Quarry 1 would not pose unacceptable Site-related carcinogenic risks; however, adverse non-carcinogenic risks from exposure of construction workers, industrial workers or future residents (child and adult) to surface soils (primarily via inhalation of particulates) is expected. Metals are the most significant contributors to the increased risks with manganese having the highest HQ. The child resident HI is 1.6; the construction worker HI is 6. The risk drivers were aluminum, manganese, and naphthalene.

Quarry 2

Levels of COCs present in Quarry 2 would not pose unacceptable Site-related carcinogenic risks; however, adverse non-carcinogenic risks from exposure of construction workers to surface and subsurface soils (primarily via inhalation of particulates) is possible. Metals are the most significant contributors to the increased risks with manganese having the highest HQ.

Quarry 3

Increased cancer risks ("ICR") for exposure to Quarry 3 soils (greater than 1E-04) were calculated for all receptors with the highest ICR of 8.0E-03 for the future resident. The calculated HI for all receptors, with the exception of the future residential child and construction worker, ranged from .8 to 4, which only somewhat exceed acceptable levels. However, the HI for the future child resident was 23 and, for the construction worker, the HI was 230. The primary exposure pathways are ingestion and inhalation of particulates. The primary COCs resulting in the increased risks are metals, including arsenic and manganese, and several PAHs (Tables 4 and 5).

Quarry 3 sediments showed similar (but lower) risks than Quarry 3 soils; however only the future child resident showed a HI greater than 1 (3). Unacceptable carcinogenic risks ranged from 1E-4 to 2E-3. The primary COCs in sediment also were arsenic and PAHs (Table 4).

Quarry 4

Increased carcinogenic risks (greater than 1.0E-04) were determined for the current industrial, and future adult and future child residents. Increased risks were highest for the resident (6.0E-04). The most significant pathway was inhalation of particulates containing chromium. Increased non-carcinogenic effects (HIs) were calculated for all receptors (adolescent trespasser, 3; construction worker, 21; industrial worker, 31; adult resident, 34; and child resident, 108). Inhalation of particulates containing manganese, aluminum, chromium, iron, and vanadium were the primary risk drivers (Tables 4 and 5).

Area 5

Although low levels of PAHs and cyanide were detected in Area 5 soils, no unacceptable Site-related carcinogenic or non-carcinogenic risks are expected for any receptor from exposure to soils from this area (Table 5).

Area 6

Sampling was limited to subsurface soils in this area; therefore, only risks to future construction workers could be calculated. An ICR of 3.59E-03 and a HI of 30.4 were calculated. The COCs are PAHs and the primary exposure route is ingestion and inhalation of particulates, 4-

methylphenol and metals (Tables 4 and 5).

Miscellaneous Surface Soil (SS-01 through SS-03)

Increased non-carcinogenic effects may be possible for the industrial worker (HI up to 9.93), adult resident (HI up to 10.8), and child resident (HI up to 35). The primary route of exposure for all receptors is via inhalation of particulates (Table 5). In addition, the SS-3 cancer risk is 1E-4.

Pipeline Area

The selected alternative includes further investigation of the WAL pipeline. Increased cancer risks were calculated for surface soil samples collected from areas impacted by the pipeline. ICRs up to 4E-03 for the future resident were calculated. Other potential receptors with unacceptable carcinogenic risks include adolescent trespasser and current industrial worker. Non-carcinogenic risks were relatively low; however, a HI greater than 1.0 was determined for child resident (7).

Uncertainty Analyses

The goal of the uncertainty analysis is to identify important uncertainties and limitations associated with the baseline human health risk assessment. There are uncertainties associated with each aspect of risk assessment, from environmental data collection through risk characterization. To support decision-making processes, significant uncertainties in the risk assessment for the Site are discussed in this section and in greater detail in the human health risk assessment available in the Administrative Record.

The distribution of sampling locations at several areas/media of interest greatly added to the uncertainty regarding whether the sampling results reflect actual Site conditions. The limited number of samples obtained at several of the locations as well as for background locations increase the uncertainty. These problems affect whether the data set is considered representative of potential Site conditions for exposed receptors and impact the uncertainty for chemicals of potential concern ("COPCs") selection, EPC calculation, and risk estimation. Too few samples collected in an area/media of interest can impact the selection of COPCs if sampling coverage missed the areas of highest contamination, causing COPCs to be eliminated that are actually significant contaminants at the Site.

An additional problem regarding too few samples collected at several areas/media of interest at the Site includes the use of background concentrations to compare to inorganic COPCs in order to screen out risks associated with Site COPCs that may be representative of background concentrations. Background groundwater samples were not collected in adequate quantity (only one sample was collected) to be considered usable for statistical comparisons in the risk assessment analysis.

Problems with data usability also add to uncertainty. For example, quantitation and/or method detection limits for several chemicals at applicable areas/media of concern were elevated above applicable screening levels. In most cases, the inclusion of these data in the quantitative risk assessment was determined to have little to no impact on estimated risks for the applicable areas/media of concern; in other cases, data points that had high detection limits were removed in order to avoid biasing the estimated risks.

The data collected at the Yellow Parcel Property in surface soil, subsurface soil, and sediment were not validated. The Yellow Parcel Property is defined as that portion of the Site which encompasses lots 45-60. Quarry 4 falls within these parcels, as does some of the previous pipeline removal work.

There are also limitations to using various models and/or equations to estimate exposure doses or contaminant concentrations. Because of the lack of reliable data regarding dermal absorption factors, the risk assessment provides default soil absorption factors for all substances except three chemicals for which well documented absorption factors are available (arsenic, cadmium, and PCBs). Even so, considerable uncertainty exists with the accuracy of estimates applied for these three chemicals. The chemical-specific parameters were literature-derived values that are measured under conditions that may or may not be representative of on-site conditions.

Uncertainties associated with the lack of groundwater modeling at the Site include the assumption that current conditions are indicative of future concentrations of contaminants. Contaminants may increase (due to migration, sediment loading, or chemical transformation) or decrease (due to migration or transformation) over time and vary from area to area.

There is also uncertainty associated with the RfDs and SFs. The uncertainty results from the extrapolation of animal data to humans, the extrapolation of carcinogenic effects from the laboratory high-dose to the environmental low-dose scenarios, and interspecies and intraspecies variations in toxicological endpoints caused by chemical exposure. The use of EPA RfD values is generally considered to be conservative because the doses are based on no-effect or lowest-observed-effect levels and then further reduced with uncertainty factors to increase the margin of safety by a factor in the neighborhood of 10 to 1,000-fold.

There are uncertainties regarding nonthreshold (carcinogenic) effects extrapolation from the high doses administered to laboratory animals to the low doses received under more common human exposure scenarios. Uncertainties due to short-time toxicological study predictions of long-term effects are also present. Additionally, there is considerable interspecies variation in toxicological endpoints used in characterizing potential health effects resulting from exposure to a chemical, and there is considerable variability in sensitivity among individuals of any particular species.

The RfDs and SFs of some chemicals have not been established, and therefore toxicity could not be quantitatively assessed. In most cases, where RfDs were unavailable for carcinogens, the carcinogenic risk is considered to be much more significant since carcinogenic effects usually occur at much lower doses.

In nature, chromium (III) ("trivalent chromium") predominates over chromium (VI) ("hexavalent chromium") (Langård and Norseth 1986). Little chromium (VI) exists in biological materials, except shortly after exposure, because reduction to chromium (III) occurs rapidly. Hexavalent chromium can also be transformed to trivalent chromium. However, hexavalent chromium is more soluble, and chromium in water samples is often found to be hexavalent. However, at Crater Resources no chromium speciation was performed at a Site. Therefore, it was conservatively assumed that chromium is present in the hexavalent form. This could tend to overestimate the noncarcinogenic risks at the Site.

Incidental ingestion of iron exceeded EPA's threshold of 1.0 under the exposure pathway for a hypothetical child resident exposed to surface soil. Currently no toxicity values for iron are published in IRIS or in HEAST. The oral reference dose used to evaluate exposures to iron was obtained from the National Center for Environmental Assessment's Superfund Technical Support Center. This value is based on an allowable daily intake and not on an adverse effect level. In addition iron is considered an essential nutrient. Consequently, iron's presence in soil may not present serious health concerns.

B. Ecological Risk Assessment

The purpose of the Ecological Risk Assessment ("ERA") is to estimate potential risks from Site contaminants to ecological receptors. A Tier I (screening ecological risk assessment) was performed for the Site and screened Site-specific data against ecological benchmark values. The use of Region III ecological screening levels represents a very conservative Tier I evaluation. The ERA consists of identification of chemicals of concern, an exposure assessment detailing the ecological setting and potential receptors, an ecological effects assessment, and an ecological risk characterization.

Identification of Chemicals of Potential Concern

Potential chemical stressors were initially identified based on the analytical data collected as part of the RI. Samples collected as part of the RI included surficial and subsurface soil samples (including accumulated "solid material" in Quarry 3) and surface water and sediment samples from the areas of ponded water within Quarry 3. COPCs were identified as part of an ecological effects assessment based on a comparison of available analytical data for surface soil, surface sediment and ponded surface water from Quarry 3 with ecological screening levels. Maximum chemical concentrations from surficial soil (i.e., soil samples beginning with the surface interval), surficial sediment (i.e., samples identified as surface sediment) and surface water samples were compared with screening levels developed by the USEPA Region III Biological Technical Assistance Group ("BTAG"), the National Oceanic and Atmospheric Administration ("NOAA"), or ecological benchmark values developed by Oak Ridge National Laboratory ("ORNL"). These screening levels were conservatively utilized as benchmarks to represent exposure concentrations that are protective of ecological receptors.

Using these screening levels, ratios of the maximum Site-specific constituent concentrations to the ecological screening levels were calculated. The resulting ratios are called environmental effects quotients ("EEQs") (see Tables 6 and 7). Those constituents with an EEQ greater than one were considered to be COPCs and are listed in Tables 8 and 9; these results are briefly summarized below by medium. The magnitude of the EEQs are considered in the Risk Characterization portion of the ERA.

The majority of organic and inorganic constituents positively detected in surface soil samples and Quarry 3 sediment samples had EEQs greater than 1. The highest exceedances (EEQ> 100) in both media were various PAHs, metals and cyanide. Fourteen organic and dissolved inorganic constituents were positively detected in surface water samples from the quarry. Of these, only seven constituents (anthracene, cyanide, barium, copper, iron, selenium, and zinc) had EEQs greater than 1. The highest exceedance (EEQ> 100) was cyanide.

Exposure Assessment

The exposure assessment evaluates the exposure of ecological receptors to COPCs. This *involved the identification of potential receptors and potential exposure pathways. Site-specific* and literature data were also evaluated for the purpose of characterizing the degree of exposure of a population or community and the characterization of potential ecological effects.

Based on the media and COPCs, two groups of potential ecological receptors were identified; terrestrial and aquatic. Mammals, birds, reptiles, amphibians and various species of invertebrates typical of suburban or small woodland settings would be expected to occur on the Site and are potential terrestrial receptors. Mammals include white-tailed deer, gray squirrels, red fox, groundhogs, chipmunks, eastern cottontail rabbit, small rodents such as field mice, moles and voles. Various bird and songbird species would also be present.

The areas of ponded water within Quarry 3 are small in size and are likely to attract only transient migratory waterfowl.

Ecological Effects Assessment

Based on information generated during the ecological field survey and present Site conditions, the primary exposure pathways identified for terrestrial receptors include direct contact with surficial soils and potential food chain exposures. For example, terrestrial invertebrates that come into direct contact with COPCs in the soil may be consumed by small mammals or birds. Other exposure routes for terrestrial receptors such as inhalation (i.e., via volatilization and/ or generation of fugitive dust) and surface runoff are not likely since the Site is well vegetated, and Quarry 3 lies in a depressional area which only receives surface water input. Because Quarry 3 lies in a depression, no surface water runoff or sediment transport from the quarry occurs.

Finally, direct contact with subsurface soils and associated groundwater do not represent realistic exposure pathways for terrestrial receptors.

Potential exposure pathways associated with surface water and sediment include direct contact (i.e., ingestion via gills and ingestion of sediment) and potential exposure to constituents of concern via the food chain. However, the areas of ponded water in Quarry 3 are small in areal extent and thus have limited potential for exposure to ecological receptors to COPCs in surface water and sediment. The most complete exposure pathways are associated with direct exposure to surface water and sediment by ephemeral aquatic insects and perhaps the early life stages of amphibians, and transient contacts by waterfowl.

Ecological Risk Characterization

The risk characterization includes two tasks; a risk characterization based on the calculation of EEQs for the terrestrial and aquatic communities, and consideration of the uncertainty associated with the ERA. Evaluation of the terrestrial ecosystem at the Crater Resources Site was based on information obtained regarding existing habitat cover-types at the Site, the identification of potential receptors, consideration of potential exposure pathways, and a qualitative evaluation of the soil data.

Quarry 1 tended to have metal concentrations above the screening levels, but no organic compounds were detected at concentrations which corresponded to EEQs greater than one. Both metals and organic compounds occurred in Quarry 2 with 28 out of 47 of the COPCs being detected above the screening levels. All but two of the 46 COPCs identified were found in Quarry 3. Of these, 36 had EEQs greater than 1. The samples collected in Quarry 4 contained a few organic compounds (PAHs) and metals above screening levels.

For terrestrial receptors, primary exposure pathways that may be associated with the on-site soils are direct contact, food chain exposure, and perhaps sediment migration of constituents to the drainage swale and maybe to Matsunk Creek. However, exposure due to the migration of constituents via surface runoff should be minimal due to the well vegetated nature of the Site and the fact that Quarry 3, with the highest levels of the COPCs, is below grade. Terrestrial invertebrates that come in direct contact with soil are likely the most susceptible potential receptors as are the predator species which feed on terrestrial fauna.

The potential exposure pathways for aquatic species and waterfowl are through direct contact with surface water or sediments (e.g., swimming, ingestion through gills, ingestion of sediment) and potential exposure to constituents of concern via the food chain. However, the drainage swale located on the Site is intermittent in nature so sustained populations of fish and aquatic invertebrates are not present although some ephemeral species of insect larvae may periodically be present.

The surface water samples from the three ponded areas in Quarry 3 contained anthracene, cyanide, barium, copper, iron, selenium, and zinc above the screening levels. The results of the sediment sampling also indicate that a number of the COPCs are above the screening levels. Transient species of waterfowl have been sighted utilizing the ponds.

C. Conclusions

Contaminants present at the Site present increased carcinogenic and non-carcinogenic risks to human health. With the exception of Area 5, at least one, but usually several potential exposure scenarios show unacceptable risks (ICR greater than 1E-04 or HI greater than 1.0). In most cases, the future residential child scenario shows the highest risk; however, future construction workers, industrial workers, and trespassers (which also represent the most likely exposure scenarios at the Site in the future) show unacceptable risks should they be exposed to various media/source areas at the Site.

D. Basis of Action

The response action selected in this Record of Decision is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

VIII. *REMEDIAL ACTION OBJECTIVES*

Remedial action objectives ("RAOs") are medium-specific environmental goals to facilitate the development of remedial alternatives that will protect human health and the environment. RAOs address the constituents of concern and potential exposure routes and receptors, which have been identified by either the Human Health Risk Assessment or the Ecological Risk Assessment. The RAOs are generally based on achieving the following: (1) the more stringent of acceptable risk-based compound levels or ranges of levels for each potential exposure route and (2) meeting ARARs.

In accordance with the above, the Site-wide RAOs are as follows, and have been developed to address the following Site-specific concerns:

Soil/Sediment

- Eliminate exposure to soil/sediment which presents an unacceptable risk to human health or the environment.
- Prevent contact of soil/sediment constituents with other media such as groundwater and surface water which may transport the contamination so that the transport does not create an unacceptable risk to human health or the environment.

Surface Water:

- Limit exposure of ecological receptors to affected surface water in the Quarry 3 pond water.

Groundwater:

- Prevent future potential exposure to ingestion of Site-related groundwater so that the exposure risk level is between 10^{-4} and 10^{-6} excess cancer risk and the hazard index is less than 1.
- Restoration of the aquifer to a beneficial use.

IX. DESCRIPTION OF ALTERNATIVES

CERCLA requires that any remedy selected to address contamination at a hazardous waste site must be protective of public health, welfare, and the environment, be cost-effective, be in compliance with regulatory and statutory provisions that are applicable or relevant and appropriate requirements ("ARARs"), and be consistent with the NCP to the extent practicable. CERCLA also expresses a preference for permanent solutions, for treating hazardous substances on-site, and for applying alternative or innovative technologies.

The Feasibility Study discusses the full range of alternatives evaluated for the Site and provides supporting information relating to the alternatives in the Proposed Plan. The Proposed Plan discussed a No Action alternative, as required by the NCP at 40 CFR §300.430 (e)(6), and other alternatives that were determined by EPA to be protective of human health and the environment, achieve state and federal regulatory requirements, and best achieve the cleanup goals for the Site. These alternatives were derived from those presented in the Draft Feasibility Study Report and the Addendum to the Draft FS Report.

The Alternatives presented in the Draft FS Report were developed to meet remedial action objectives, or specific environmental goals established for the affected media at the Site. These objectives are based on achieving preliminary remediation goals ("PRGs") established in the Draft FS Report and modified in the Addendum. PRGs may include soil screening levels developed for soil to groundwater pathway scenarios and risk-based concentrations developed from the human health risk assessment. Risk-based PRGs were developed to meet a target excess cancer risk of 1 in 100,000 (expressed in scientific notation as 1E-05) additional human cancer cases or a target hazard index value of 1. The calculations of the PRGs and the PRG tables can be found in Appendix C of the Draft FS Report, with modifications in the Addendum.

The alternatives are presented in the categories of Site-wide Alternatives, Soil/Sediment Alternatives, and Groundwater Alternatives. A description of each alternative including costs is presented. A list of key remedy components, distinguishing features, and expected outcomes for each alternative, with the exception of the No Action alternative (SW-1) and further pipeline investigation alternative (SW-3), follow each description.

SITE-WIDE ALTERNATIVES

Alternative SW-1: No Action

Capital Cost	$ 0
Total Present Worth Cost	$ 0
Annual Operation & Maintenance (O&M) Cost	$ 0

40 CFR Section 300.430 (e)(6) of the NCP requires the development of a No Action alternative for remedial actions. Under the No Action alternative, no remedial action will be taken to remove, control mitigation from, or minimize exposure to contaminated soils and sediment. The No Action alternative establishes a baseline or reference point against which each of the remedial action alternatives are compared. In the event that the other identified alternatives do not offer substantial benefits in the reduction of toxicity, mobility, or volume of the constituents of concern, the No Action alternative may be considered a feasible approach.

Under this Alternative, no effort would be made to control the future use of the contaminated area. Existing contaminated soils and sediments would remain in place in all of the affected areas. No capitol costs would be incurred and no ARARs would be considered under this alternative. Since contaminated media would be left on-site, a review of Site conditions would be required no less than every five years pursuant to Section 121(c) of CERCLA, 42 U.S.C. §9621 (c).

Alternative SW-2: Institutional Controls

Capital Cost	$ 145,000
Total Present Worth Cost	$ 230,000
Annual O&M Cost	$ 2,000

Institutional controls would be implemented to restrict on-site soil, sediment, surface water and groundwater use and/or disturbance at the Site, and to restrict off-site groundwater use except as required for implementation of the remedy, in order to reduce the potential for human exposure to contamination (i.e. easements, restrictions, covenants, title notices, etc.). With respect to groundwater, such controls may consist of limitations on well drilling, prohibitions, or limitations on certain uses of groundwater. With respect to soils and sediments, institutional controls may consist of restrictions on excavation or removal of contaminated soils from the affected areas and prohibitions on any activity that may disturb the soils and/or sediments. Since contaminated media would be left on-site, a review of Site conditions would be required no less than every five years.

Description of Remedy Components:

- Institutional controls including easements, covenants, title notices, and prohibitions or limitations of groundwater use are required.

Distinguishing Features of the Alternative:

- This alternative may be reliable for the long-term if institutional controls are enforced.
- The alternative will not comply with groundwater ARARs (attainment of MCLs and/or MCLGs) since no groundwater remediation is to occur.
- No construction will occur.

Expected Outcome of the Alternative

- Remediation goals will not be reached as no treatment is to occur.
- Institutional controls must stay in effect; groundwater will not be restored to beneficial use.

Alternative SW-3: WAL Pipeline Investigation

Total Present Worth Cost: $148,000

This alternative calls for further investigation of the WAL pipeline that runs from the Alan Wood Steel facility to the Site. During the Remedial Investigation, portions of an underground pipeline were found along the former pipeline route. Some sections of the pipeline have been removed by the Crater PRP Group and other private parties. However, the entire route of the former WAL pipeline has never been fully investigated. This alternative would require a full investigation of the former pipeline route, with soil samples taken to determine the existence of any contamination along the route. Any pipeline soil areas with contaminant levels above human health or ecological risk-based concentrations would be removed and taken off-site for proper disposal or recycling. In addition, any hardened tar material from past WAL pipeline leaks will be transported to an off-site disposal facility. The investigation would be conducted during the design phase of the remedy, and if required, remediation of portions of or the entire pipeline route would be conducted as part of the cleanup at the Site, and all applicable or relevant and appropriate requirements regarding removal of the pipeline and associated soils would apply.

SOIL/SEDIMENT ALTERNATIVES

Alternative S-3: Soil Cover

Capital Cost	$ 5,295,000
Total Present Worth Cost	$ 5,407,000
Annual O&M Cost	$ 9,900

Time to Implement: less than 1 year for construction

This alternative would cover Quarries 1, 2, 3, and 4, and all other contaminated soil areas with a layer of clean fill and soil. The Quarry 3 ponds would be dewatered, and the water would be transported to an off-site disposal facility in accordance with all federal and state regulations. The dewatered ponds would be filled with clean soil and regraded for proper stormwater drainage. Quarries 1, 2, and 4 and other contaminated soil areas would be filled and regraded as needed. Due to the limited sampling in the areas of the pipeline valves and drainage swale east of Quarry 3, further delineation of the extent of contamination in the areas of these impacted soils will be required as part of the design. Data collected from this delineation will determine the area required for source control. Institutional controls to restrict soil disturbance and excavation activities, except as required by implementation of the remedy, would be required for these areas.

This alternative would prevent direct contact with all contaminated surface soil/sediment and enable drainage across affected areas to channel water away from the contamination. Since contaminated media would be left on-site, a review of Site conditions would be required no less than every five years.

Description of Remedy Components:

- Dewater ponds in Quarry 3 and dispose off-site.
- Cover quarries and other contaminated soils with clean fill and soil.
- No source reduction will occur.
- O&M activities to maintain cover material are required.
- Institutional controls including easements, deed restrictions, title notices, and prohibitions or limitations of groundwater use are required.
- Conduct a pre-design investigation to determine the extent of contaminated soils located outside the known quarry areas.

Distinguishing Features of the Alternative:

- This alternative may be reliable for the long-term if institutional controls are enforced; however, there is residual risk as contaminated soils are left in place.
- The alternative will not achieve groundwater ARARs (attainment of MCLs and/or MCLGs) quickly.
- ARARs for soil erosion and sediment controls must be met.
- The alternative must comply with all federal and state regulations for off-site disposal of materials from dewatering ponds.
- Remedy can be implemented with relative ease in less than one year.

Expected Outcome of the Alternative

- Soil remediation goals will not be reached as no treatment is to occur, although exposure will be prevented.
- Institutional controls must stay in effect.
- Groundwater will not be quickly restored to beneficial use.

Alternative S-4: Low-Permeability Cap

Capital Cost	$ 7,353,000
Total Present Worth Cost	$ 7,501,000
Annual O&M Cost	$ 11,900
Time to Implement:	less than 1 year for construction

This alternative calls for a low-permeability or multi-media cap on all quarries and contaminated soil/sediment areas to prevent unacceptable leaching of contaminants from the soils and sediment into the groundwater. In addition, implementation of this alternative would prevent direct contact to human health and environmental receptors.

A multi-media cap contains a series of layers to prevent the surface water from reaching the contamination below the surface. A multi-media cap consists of a series of low-permeability clays, geotextile liners, sand drainage layers, and soil or other appropriate covers. The Draft FS Report calls for a multi-media cap on Quarry 3 and asphalt capping on the remaining areas or those areas where development of the office park is anticipated. However, due to the uncertainty of future actions at the Site, EPA has chosen multi-media capping for all affected areas. Asphalt could be added into the design of the cap in the future, once plans for the area are confirmed.

Ponds 1, 2, and 3 in Quarry 3 would be dewatered and the water would be transported to an off-site disposal facility in accordance with all federal and state regulations. All areas throughout the Site requiring a cap would be graded to appropriate elevations prior to cap installation. Due to the limited sampling in the areas of the pipeline valves and drainage swale east of Quarry 3, further delineation of the extent of contamination in the areas of these impacted soils will be required as part of the remedial design. Data collected from this delineation will determine the area required for source control. Institutional controls (i.e., use restrictions, title notices, and proprietary controls) would be implemented to ensure that the cap integrity is maintained. Construction or use of the property that in any way is inconsistent with the proposed remedy and the integrity of the cap would be prohibited. In addition, long-term maintenance of the capped areas would be conducted to ensure continued effectiveness. Since contaminated media would be left on-site, a review of Site conditions would be required no less than every five years.

Description of Remedy Components:

- Dewater ponds in Quarry 3 and dispose of the water off-site.
- Cover contaminated areas with multi-media low-permeability cap.

- O&M activities to maintain cap are required.
- Institutional controls including easements, covenants, title notices, and prohibitions or limitations of groundwater use and capped areas are required.
- Conduct a pre-design investigation to determine the extent of contaminated soils located outside the known quarry areas.

Distinguishing Features of the Alternative:
- This alternative may be reliable for the long-term if institutional controls are enforced; however, there is residual risk as contaminated soils are left in place, although exposure will be prevented.
- The alternative must comply with all federal and state regulations for off-site disposal of materials from dewatering ponds.
- Remedy can be implemented with relative ease in less than one year.
- Source control is through containment rather than reduction.

Expected Outcome of the Alternative
- Soil remediation goals will not be reached as no treatment is to occur, although exposure will be prevented.
- *Institutional controls must stay in effect.*
- Capping will prevent leaching of contaminants into groundwater. Groundwater cleanup levels may be reached within four years for organics.

Alternative S4-A: Quarry 3 Sediment Removal/Low-Permeability Capping

Capital Cost	$ 9,064,000
Total Present Worth Cost	$ 9,211,000
Annual O&M Cost	$ 11,900
Time to Implement:	less than 1 year for construction

This alternative calls for removal of the contaminated sediments from the ponds in Quarry 3, and low-permeability capping of all other contaminated areas of the Site. This alternative would prevent direct contact with all contaminated soils and sediments, and help to prevent leaching of contaminants from the soils and sediment to the groundwater.

Ponds 1, 2, and 3 would be dewatered and the water would be transported to an off-site disposal facility in accordance with all federal and state regulations. The sediments would be excavated from the bottom of the ponds down to a level that meets risk-based concentrations. The sediments would be dewatered, sampled to determine appropriate disposal, and disposed of off-site or recycled. The ponds would then be backfilled with clean fill. The Quarry 3 plateau areas and surface soils would be regraded and capped with a low-permeability cap as described in Alternative S-4, as would Quarries 1, 2, and 4 and all other remaining contaminated areas. Due to the limited sampling in the areas of the pipeline valves and drainage swale east of Quarry 3, further delineation of the extent of contamination in the areas of these impacted soils will be required as part of the remedial design. Data collected from this delineation will determine the area required for source control.

Institutional controls (i.e., use restrictions, title notices, and proprietary controls, such as easements and covenants) would be implemented to ensure that the cap integrity is maintained. Construction or use of the property that in any way is inconsistent with the remedy and the integrity of the cap would be prohibited. In addition, long-term maintenance of the capped areas would be conducted to ensure continued effectiveness. Since contaminated media would be left on-site, a review of Site conditions would be required no less than every five years.

Description of Remedy Components:

- Dewater ponds in Quarry 3 and dispose of water off-site in accordance with all federal and state regulations, and remove sediments in Quarry 3 and dispose off-site.
- Backfill Quarry 3 with clean soil and cover other contaminated areas with low-permeability cap.
- O&M activities to maintain cap are required.
- Institutional controls including easements, covenants, title notices, and prohibitions or limitations of groundwater use and capped areas are required.
- Conduct a pre-design investigation to determine the extent of contaminated soils located outside the known quarry areas.

Distinguishing Features of the Alternative:

- This alternative may be reliable for the long-term if institutional controls are enforced; however, there is residual risk as contaminated soils are left in place, although exposure will be prevented.
- ARARs for soil erosion and sediment controls must be met.
- The alternative must comply with all federal and state regulations for off-site disposal of materials from dewatering ponds.
- Remedy can be implemented with moderate difficulty in less than one year.

Expected Outcome of the Alternative

- Soil remediation goals will not be reached as no treatment is to occur, although exposure will be prevented.
- Institutional controls must stay in effect.
- Capping will prevent leaching of contaminants into groundwater. Groundwater cleanup levels may be reached within four years for organics.

Alternative S-4B: Quarry 3 Sediment Stabilization/Low-Permeability Capping

Capital Cost	$ 10,342,000
Total Present Worth Cost	$ 10,489,000
Annual O&M Cost	$ 11,900
Time to Implement:	less than 1 year for construction

This alternative calls for stabilization of the Quarry 3 pond sediments and low-permeability capping of all contaminated soil areas. Sediment stabilization and low-permeability capping would prevent direct contact with contaminated soils and sediments, and help to prevent leaching of contaminants into the groundwater.

Ponds 1, 2, and 3 in Quarry 3 would be dewatered and the water would be transported to an off-site disposal facility in accordance with all federal and state regulations. A stabilization agent would then be added to the sediments in the ponds that contain contaminant levels above risk-based concentrations. Stabilizing the sediments would prevent leaching of the contaminants from the sediments to the groundwater. Prior to remediation being preformed, a treatability study may be required to verify the stabilization mix. The Quarry 3 plateau area and surface soils would remain in place, and be capped with a low-permeability cap as described in Alternative S-4, as would Quarries 1, 2, and 4 and all other remaining contaminated areas. Due to the limited sampling in the areas of the pipeline valves and drainage swale east of Quarry 3, further delineation of the extent of contamination in the areas of these impacted soils will be required as part of the design. Data collected from this delineation will determine the area required for source control.

Institutional controls (i.e., use restrictions, title notices, and proprietary controls, such as covenants and easements) would be implemented to ensure that the cap integrity is maintained. Construction or use of the property that in any way is inconsistent with the proposed remedy and the integrity of the cap would be prohibited. In addition, long-term maintenance of the capped areas would be conducted to ensure continued effectiveness. Since contaminated media would be left on-site, a review of Site conditions would be required no less than every five years.

Description of Remedy Components:

- Dewater ponds in Quarry 3 and dispose off-site in accordance with all federal and state regulations.
- Stabilize Quarry 3 sediments and cover other contaminated areas with low-permeability cap.
- O&M activities to maintain cap are required.
- Institutional controls including easements, covenants, title notices, and prohibitions or limitations of groundwater use and capped areas are required.

- Conduct a pre-design investigation to determine the extent of contaminated soils located outside the known quarry areas.

Distinguishing Features of the Alternative:

- This alternative may be reliable for the long-term if institutional controls are enforced; however, there is residual risk as contaminated soils are left in place, although exposure will be prevented.
- ARARs for soil erosion and sediment controls must be met.
- The alternative must comply with all federal and state regulations for off-site disposal of materials from dewatering ponds.
- Remedy can be implemented with moderate difficulty in less than one year.

Expected Outcome of the Alternative

- Institutional controls must stay in effect.
- Capping and stabilization will prevent leaching of contaminants into groundwater.
- Groundwater cleanup levels may be reached within four years for organics.

Alternative S-5: Quarry 3 Removal/Low-Permeability Capping

Capital Cost	$ 8,855,000
Total Present Worth Cost	$ 9,002,000
Annual O&M Cost	$ 11,900
Time to Implement:	less than 1 year for construction

This alternative calls for removal of contaminated soils and sediments in Quarry 3 and low-permeability capping of Quarries 1, 2, and 4 and all other contaminated areas to prevent direct contact with contamination and unacceptable leaching of contaminants into the groundwater beneath the Site.

As in the previous alternatives, Ponds 1, 2, and 3 would be dewatered and the water would be transported to an off-site disposal facility in accordance with all federal and state regulations. The sediments at the bottom of the ponds would be excavated down to the bedrock layer or to the level where contaminant concentrations in the sediments are below human health or ecological risk-based concentrations, dewatered, and taken off-site for proper disposal or recycling. The Quarry 3 plateau area would be excavated down to the bedrock layer or to the level where the contaminant concentrations in the soils are below human health or ecological risk-based concentrations, and the soil would be taken off-site for proper disposal or recycling. All remaining soil areas in Quarry 3 with contaminant levels above human health or ecological risk-based concentrations would be removed and taken off-site for proper disposal or recycling. The excavated areas would then be filled with clean soil and graded for proper drainage.

Quarries 1, 2, and 4 and all other remaining contaminated areas would be graded and capped as described in Alternative S-4 above. *Due to the limited sampling in the areas of the pipeline* valves and drainage swale east of Quarry 3, further delineation of the extent of contamination in the areas of these impacted soils will be required as part of the design. Data collected from this delineation will determine the area required for source control. Institutional controls (i.e., use restrictions, title notices, and proprietary controls, such as covenants or easements) would be implemented to ensure that the cap integrity is maintained. Construction or use of the property that in any way is inconsistent with the proposed remedy and the integrity of the cap would be prohibited. In addition, long-term maintenance of the caps would be conducted to ensure continued effectiveness. Since contaminated media would be left on-site, a review of Site conditions would be required no less than every five years.

Description of Remedy Components:

- Dewater ponds in Quarry 3 and dispose of the water off-site, and remove soils and sediments in Quarry 3 and dispose off-site.
- Backfill Quarry 3 with clean soil and cover other contaminated areas with low-permeability cap.
- O&M activities to maintain cap are required.
- Institutional controls including easements, covenants, title notices, and prohibitions or limitations of groundwater use and capped areas are required.
- Conduct a pre-design investigation to determine the extent of contaminated soils located outside the known quarry areas.

Distinguishing Features of the Alternative:

- The source presenting the greatest risks and containing principal threat wastes (Quarry 3 soils and sediments) will be removed.
- This alternative may be reliable for the long-term if institutional controls are enforced; however, there is residual risk as contaminated soils are left in place, although exposure will be prevented.
- ARARs for soil erosion and sediment controls must be met.
- The alternative must comply with all federal and state regulations for off-site disposal of materials.
- Remedy can be implemented with moderate difficulty in less than one year.

Expected Outcome of the Alternative

- Soil remediation goals will not be reached for all areas, although exposure will be prevented; however, the most contaminated source (Quarry 3 soils and sediments) will be removed.
- Institutional controls must stay in effect.
- Groundwater cleanup levels may be reached within four years for organics.

Alternative S-6 : Complete Removal

Capital Cost	$ 69,103,000
Total Present Worth Cost	$ 69,103,000
Annual O&M Cost	$ 0
Time to Implement:	less than 1 year for construction

This alternative calls for removal of all contaminated soils and sediments in order to prevent further leaching of contaminants from soil to groundwater, and to remove any direct contact risk.

Ponds 1, 2, and 3 would be dewatered and taken off-site for proper disposal in accordance with all federal and state regulations. The sediments will be taken off-site for proper disposal or recycling as described in the above alternatives. Soils in Quarries 1, 2, 3, and 4 and throughout the Site that have contamination levels above the risk-based concentrations or preliminary remediation goals described in the Draft FS Report would be excavated and taken off-site for disposal or recycling. Due to the limited sampling in the areas of the pipeline valves and drainage swale east of Quarry 3, further delineation of the extent of contamination in the areas of these impacted soils will be required as part of the remedial design. Data collected from this delineation will determine the area required for source control. All excavated areas would then be backfilled with clean fill and graded for proper stormwater drainage.

Although all contaminated soils would be removed, contaminated groundwater would remain beneath the Site. Therefore, a review of Site conditions would be required no less than every five years.

Description of Remedy Components:

- Dewater ponds in Quarry 3 and dispose of water off-site, and remove all contaminated soils and dispose off-site.
- Institutional controls including prohibitions or limitations of groundwater use are required.
- No O&M is required.
- Conduct a pre-design investigation to determine the extent of contaminated soils located outside the known quarry areas.

Distinguishing Features of the Alternative:

- All soils exceeding risk-based concentrations or remediation goals will be removed.
- This alternative is reliable for the long-term to eliminate risks to exposure to contaminated soils.
- ARARs for soil erosion and sediment controls must be met.
- The alternative must comply with all federal and state regulations for off-site disposal of materials.

- Remedy can be implemented with relative ease in less than one year.
- A large volume of soils would need to excavated, transported, and treated off-site resulting in high costs.

Expected Outcome of the Alternative
- Soil remediation goals will be met.
- Groundwater cleanup levels may be reached within four years for organics.

Alternative S-7: Stabilization

Capital Cost	$ 79,873,000
Total Present Worth Cost	$ 104,030,000
Annual O&M Cost	$ 9,900
Time to Implement:	less than 1 year for construction

This alternative would treat the contaminated soils and sediment through in-situ (below ground) methods. In situ treatment would immobilize the contaminants in the soils and sediments and prevent them from migrating into the groundwater. Soils in Quarries 1, 2, 3, and 4 and throughout the Site that have levels of contaminants above risk-based concentrations or preliminary remediation goals would be stabilized and then topped with a soil cover to prevent direct contact with the stabilized soils. Due to the limited sampling in the areas of the pipeline valves and drainage swale east of Quarry 3, further delineation of the extent of contamination in the areas of these impacted soils will be required as part of the remedial design. Data collected from this delineation will determine the area required for source control. Prior to the in situ stabilization process, the ponds in Quarry 3 would be dewatered and the water would be transported to an off-site disposal facility in accordance with all federal and state regulations. A treatability study to determine the stabilization mix appropriate for the Site soils and sediments may be required prior to remediation.

Institutional controls to restrict disturbance of the stabilized areas (i.e., prohibitions on excavation and drilling, etc.) would be required. Since contaminated media would be left on-site, a review of Site conditions would be required no less than every five years.

Description of Remedy Components:
- Dewater ponds in Quarry 3 and dispose water off-site.
- Perform in-situ stabilization of soils and sediments and add soil cover.
- Institutional controls including easements, covenants, title notices, and prohibitions or limitations of groundwater use and treated areas are required.
- O&M to monitor groundwater and inspect soil cover.
- Conduct a pre-design investigation to determine the extent of contaminated soils located outside the known quarry areas.

Distinguishing Features of the Alternative:

- All soils exceeding risk-based concentrations or remediation goals will be stabilized, but not removed. Stabilization increases mass/volume of materials on-site.
- This alternative is reliable for the long-term to eliminate risks to exposure to contaminated soils.
- ARARs for soil erosion and sediment controls must be met.
- The alternative must comply with all federal and state regulations for off-site disposal of pond water.
- Remedy can be implemented with relative difficulty in less than one year.
- A large volume of soils would need to be treated resulting in high costs.

Expected Outcome of the Alternative

- Risks posed by contaminated soils will be eliminated if the materials are properly stabilized.
- Groundwater cleanup levels will not be reached within a reasonable time period.

GROUNDWATER ALTERNATIVES

Alternative GW-3: Monitored Natural Attenuation

Capital Cost	$ 50,000
Total Present Worth Cost	$ 600,000
Annual O&M Cost	$ 26,600
Time to Implement:	0 years (no construction required)

This alternative provides for natural attenuation and groundwater monitoring in accordance with the ten criteria contained in EPA's guidance titled "Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites" dated April 21, 1999. Natural attenuation relies on natural processes to decontaminate contaminated groundwater. These processes include dilution, biodegradation, volatilization, adsorption, and chemical reactions with subsurface materials. This alternative includes the monitoring of contaminants of concern to verify that natural attenuation is decreasing the concentrations of the contaminants at an acceptable rate, while providing sufficient protection to human health and the environment. Specifically, groundwater samples are collected and analyzed for biological and chemical indicators to confirm that contaminant biodegradation is reducing contaminant mass, mobility, and risk at an acceptable rate.

Groundwater monitoring would occur at locations, both on-site and off-site, in order to sample for selected Site-related SVOCs, metals, cyanide, and VOCs that presently exceed preliminary remediation goals. This monitoring would provide a basis to determine whether or not natural attenuation is taking place at an acceptable rate.

The ultimate objective for the groundwater portion of this remedial action is to restore contaminated groundwater to its beneficial use. The aquifer could be used as a potential source of drinking water, but is currently not used for this purpose. Based on information obtained during the RI and a careful analysis of other groundwater alternatives, this remedy is expected to achieve this objective within a reasonable time frame. The organic contaminants present in groundwater at levels above remediation goals would be subject to biodegradation. Inorganic contaminant levels would be expected to stabilize if this remedy is combined with soil source control. Current estimates for cleanup of organic COCs using this alternative combined with *source control is 3 to 4 years which is similar to the other groundwater alternatives (see the FS* for further information). Appendix F of the RI presents a detailed monitored natural attenuation evaluation.

In accordance with the Monitored Natural Attenuation Guidance, EPA has chosen a time limit of 15 years for natural attenuation to meet the remedial goals. If, during the15-year time period, it is evident that natural attenuation is not occurring at a sufficient rate to meet the remedial objectives, EPA will default to the contingent groundwater remedy, which is described in Alternative GW-5 (Groundwater, Recovery, Treatment, and Discharge). EPA will also evaluate the rate of natural attenuation during the Five-Year Reviews for the Site.

Institutional controls would be required to prevent exposure to groundwater contamination (i.e., prohibitions on well drilling, well installation, etc.), except as required by the remedy. Since contaminated media would be left on-site, a review of Site conditions would be required no less than every five years.

Description of Remedy Components:
- Monitoring of on- and off-site wells to evaluate whether contaminants are naturally degrading.
- No groundwater treatment will occur.
- O&M for groundwater monitoring.
- Institutional controls including prohibitions or limitations of groundwater use are required.

Distinguishing Features of the Alternative:
- No construction costs or time are required.
- A time limit of 15 years will be used to meet the remedial objectives.
- Source control is required to expedite groundwater cleanup time.
- Compliance with EPA's Monitored Natural Attenuation Guidance is required.

Expected Outcomes of the Alternative

- Groundwater remediation goals would be met over a long time period if no source controls are implemented. If source controls are in place, organic remediation goals may be met within 3 to 4 years.
- Soil risks will not be reduced unless this alternative is used in conjunction with source control.

Alternative GW-4: Downgradient Groundwater Recovery

Capital Cost	$ 1,607,000
Total Present Worth Cost	$ 3,380,000
Annual O&M Cost	$ 64,800
Time to Implement:	less than 1 year for construction

This alternative would require an increase in the pumping rate of the pond well located southeast of the Site. The pump in this well is currently used only when needed to replenish water in the pond on the Gulph Mills Golf Course. This alternative suggests pumping the water in the well at a constant rate, and by doing so, containing the groundwater plume to keep it from migrating further off-site. The excess water pumped from the well would be treated to meet treatment goals specified in Table 13. The treatment method specified in the Draft FS Report is filtration to remove suspended solids, however the exact treatment method to be used would be determined in the remedial design ("RD"). Examples of other possible treatment methods include air stripping, filtration, granular activated carbon adsorption, and chemical oxidation. The treatment system would likely be located on-site with discharge of the treated water to the Schuylkill River or Matsunk Creek.

Groundwater monitoring would be necessary to verify that the plume is being contained. Institutional controls would be required to prevent unauthorized exposure to groundwater contamination (i.e., prohibitions on well drilling, well installation, etc.). Since contaminated media would be left on-site, a review of Site conditions would be required no less than every five years.

Description of Remedy Components:

- Pumping existing well to recover groundwater.
- On-site treatment of recovered groundwater by removing sediments prior to discharge to surface water.
- Monitoring of groundwater to determine if capture and reduction of contamination is occurring.
- O&M includes groundwater monitoring, pump maintenance, and pre-treatment of discharge.

- Institutional controls including prohibitions or limitations of groundwater use are required.

Distinguishing Features of the Alternative:
- Relatively minimal construction time to implement.
- Must comply with ARARs for discharge to surface water and all federal and state regulations for disposal of filtration residues.
- Source control is required to expedite groundwater cleanup time.

Expected Outcomes of the Alternative
- Groundwater remediation goals would be met over a long time period if no source controls are implemented. If source controls are in place, organic remediation goals may be met within 3 years.
- Soil risks will not be reduced unless this alternative is used in conjunction with source control.

Alternative GW-5: Groundwater Recovery, Treatment, and Discharge

Capital Cost	$ 2,184,000
Total Present Worth Cost	$ 7,270,000
Annual O&M Cost	$ 221,700
Time to Implement:	less than 1 year for construction

This alternative calls for groundwater recovery and treatment from the center of the groundwater plume at the Site. The purpose is to extract and treat the most highly contaminated groundwater from beneath the Site. The recovery system would pump the water near the downgradient edges of Quarries 2 and 3 using a line of recovery wells spread across the width of the plume. The groundwater would then be pumped to an on-site treatment facility to remove contaminants to specified treatment levels and the treated water would be discharged to the Schuylkill River or Matsunk Creek. Groundwater treatment options include, among others, chemical oxidation, air stripping, and granular activated carbon adsorption.

Groundwater monitoring would be necessary to be sure the contamination levels within the plume are decreasing. Institutional controls would be required to prevent exposure to the contaminated groundwater plume (i.e., restrictions on drilling of wells, etc.) Institutional controls would also be required to prevent disturbance of the recovery wells and on-site treatment facility. Since contaminated media would be left on-site, a review of Site conditions would be required no less than every five years.

Description of Remedy Components:

- Construction of groundwater recovery system to extract groundwater from the center of the plume.
- On-site treatment of recovered groundwater for removal of contaminants prior to discharge to surface water.
- Monitoring of groundwater to determine if capture and reduction of contamination is occurring.
- O&M includes groundwater monitoring and maintenance of the recovery and treatment system.
- Institutional controls including prohibitions or limitations of groundwater use are required.

Distinguishing Features of the Alternative:

- May be constructed in less than one year with relatively low difficulty.
- Must comply with ARARs for discharge to surface water and all federal and state regulations for disposal of filtration residues.
- Source control is required to expedite groundwater cleanup time.

Expected Outcomes of the Alternative

- Groundwater remediation goals would be met over a long time period if no source controls are implemented. If source controls are in place, organic remediation goals may be met within 2 to 3 years.
- Soil risks will not be reduced unless this alternative is used in conjunction with source control.

X. COMPARATIVE EVALUATION OF ALTERNATIVES

Each of the remedial alternatives summarized in this ROD have been evaluated against the nine evaluation criteria set forth in the NCP (see 40 C.F.R. Section 300.430(e)(9)). These nine criteria can be categorized into three groups - threshold criteria, primary balancing criteria, and modifying criteria. A description of the evaluation criteria is presented below:

Threshold Criteria:

1. Overall Protection of Human Health and the Environment addresses whether a remedy provides adequate protection and describes how risks are eliminated, reduced, or controlled.
2. Compliance with Applicable or Relevant and Appropriate Requirements (ARARs) addresses whether a remedy will meet all of the applicable, or relevant and appropriate requirements of federal environmental laws, as well as state environmental or facility siting laws.

Primary Balancing Criteria:

3. Long-term Effectiveness and Permanence refers to the ability of a remedy to maintain reliable protection of human health and the environment over time once clean up levels are achieved.
4. Reduction of Toxicity, Mobility, or Volume through Treatment addresses the degree to which alternatives employ recycling or treatment that reduces toxicity, mobility, or volume of contaminants.
5. Short-term Effectiveness addresses the period of time needed to achieve protection and any adverse impacts on human health and the environment that may be posed during implementation of the alternative.
6. Implementability addresses the technical and administrative feasibility of a remedy, including the availability of materials and services needed to implement that remedy.
7. Cost refers to an evaluation of several categories of costs associated with a particular alternative. The cost categories include capital costs, including direct and indirect costs; annual operation and maintenance costs; and net present value of capital and O&M costs.

Modifying Criteria:

8. State Acceptance indicates whether the State concurs with, opposes, or has no comment on EPA's preferred alternative.
9. Community Acceptance assesses public reaction - evidenced by public comment on the Administrative Record file and the Proposed Plan - to each of the alternatives considered for the Site.

A description of each criterion and associated evaluation of the alternatives for the Site is provided below.

Overall Protection of Human Health and the Environment

Overall protection of human health and the environment addresses whether each alternative provides adequate protection of human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled, through treatment, engineering controls, and/or institutional controls.

Alternative SW-1 would provide no basis for monitoring existing conditions at the Site, other than during Five-Year reviews, and therefore would provide no assurances that contaminated media would remain undisturbed, and that risks to human health would not change. Alternative SW-2 would provide institutional controls to prevent direct contact with contaminated media, however, no remediation would take place. SW-3 provides for investigation of the former WAL pipeline, and could provide for protection if portions of the pipeline and associated contaminated soils are found and removed. Alternatives S-4, S-4A, S-4B, S-5 and S-7 all provide protectiveness through capping by preventing direct contact with contaminated materials and reducing further leaching of contaminants in soil to the groundwater. The soil cover in S-3 would prevent direct contact with contaminated media, but would still allow leaching of soil contamination to groundwater since the permeability of a soil cover is relatively high. Alternatives S-4A, S-5, and S-6 all provide a high level of protectiveness since portions of the contaminant source areas in the soils would be removed, with S-6 providing the highest level of protectiveness. Ongoing maintenance of the capping alternatives would be required to ensure long-term protectiveness.

For groundwater, Alternative GW-5 provides for the most contaminant mass removal since the extraction wells would be located in the center of the groundwater plume. Alternative GW-4 would provide a slower mass removal of contaminants, since only one extraction well would be located at the downgradient side of the plume. Alternative GW-3 is protective, since the surrounding community obtains drinking water from municipal water lines, and therefore no current ingestion risk from the groundwater exists. In addition, the groundwater is 70 feet below the ground surface in most parts of the Site, so there are no significant risks for direct contact with the contaminated groundwater. No adverse environmental impacts would occur from implementation of any of the groundwater alternatives, since any surface discharge would be monitored to meet NPDES requirements.

Compliance with Applicable or Relevant and Appropriate Requirements (ARARS)

Section 121(d) of CERCLA and the NCP at 40 CFR §300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate Federal and State requirements, standards, criteria, and limitations which are collectively referred to as "ARARs," unless such ARARs are waived under CERCLA section 121(d)(4).

Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those State standards that are identified by a state in a timely manner and that are more stringent than Federal requirements may be applicable. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under Federal environmental or State environmental or facility siting laws that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well-suited to the particular site. Only those State standards that are identified in a timely manner, are consistently enforced, and are more stringent than Federal requirements may be relevant and appropriate.

Compliance with ARARs addresses whether a remedy will meet all of the applicable or relevant and appropriate requirements of other Federal and State environmental statutes or provides a basis for a invoking waiver.

Major ARARs that may apply to the alternative groundwater remedies listed in this ROD include: Federal Maximum Contaminant Levels ("MCLs") and Maximum Contaminant Level Goals ("MCLGs"); Section 402 of the Clean Water Act (National Pollutant Discharge Elimination System) substantive requirements; 25 Pa. Code Chapter 93 (compliance with established water quality standards). Earth moving activities in the soil alternatives would need to comply with the substantive requirements of 25 Pa. Code Chapter 102 (concerning erosion and sediment control) and 32 P.S. § 680.13 (PA Stormwater Management) . The multi-layer capping alternatives would need to meet the substantive requirements of 25 Pa. Code Chapter 288 (residual waster regulations for class 1 landfill caps). To the extent necessary, soils and sediments excavated from the quarries and ponds would be sampled to determine the appropriate disposal method. Table 14 provides a complete listing of the ARARs for the Site.

SW-1, SW-2, and SW-3 would not meet applicable groundwater standards, since no remediation would be performed, although S-3 could result in a remedial action as a result of the pipeline investigation..

None of the groundwater alternatives, GW-3, GW-4, and GW-5, provide short-term compliance with ARARs when not coupled with a soil alternative, since without a soil alternative, leaching of the contaminants from the soils to the groundwater would not be reduced. Alternatives GW-4 and GW-5 would meet NPDES requirements. Alternative GW-3, would be evaluated and monitored in accordance with EPA's "Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites" dated April 21,1999.

For soils and sediments, Alternatives S-4A, S-5, and S-6 would meet action-specific ARARs associated with excavation, transport and treatment of soils. Alternatives S-4, S-4A, S-4B, and S-5 would meet the PADEP requirements for cap permeability.

Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time, once clean-up levels have been met. This criterion includes the consideration of residual risk that will remain on-site following remediation and the adequacy and reliability of controls.

For the Site-wide Alternatives, SW-1 would leave the Site in its current condition, and no long-term effectiveness would result, since no treatment or restrictions to prevent direct contact with contamination would occur. SW-2 may be effective in the long-term for soils if the institutional controls to restrict access to Site-related contamination are enforced. SW-3 would be effective in determining how much of the WAL pipeline and any associated contamination remains, and would achieve long-term effectiveness and permanence if the any portions of the pipeline and associated contaminated soils are found and removed.

For soils and sediments, Alternatives S-4 through S-7 are expected to be effective since restrictions would be required to prevent exposure to contaminated media. Alternative S-6 would be the most effective and protective in the long-term since complete removal of all contaminated soils would take place. Alternatives S-5 and S-4A are effective and permanent in the long-term since removal or partial removal of contaminated soils would take place. Alternatives S-4B and S-7 would prevent leaching of some or all soil contaminants to the groundwater since contaminated soil would be stabilized. Alternative S-3 has the highest residual risk of the soil/sediment alternatives since only a soil cover is used for waste containment.

For groundwater, GW-3, GW-4, and GW-5 achieve long-term effectiveness and permanence since removal of contaminants from the groundwater would take place. The groundwater alternatives are more effective when coupled with a soil alternative, since the soil alternatives either remove a source area or prevent contaminants from leaching from soil areas into the groundwater. GW-4 and GW-5 may provide a more effective long-term remedy than GW-3; this will more fully evaluated during the MNA demonstration.

Reduction of Toxicity, Mobility, or Volume through Treatment

Reduction of toxicity, mobility, or volume through treatment refers to the anticipated performance of the treatment technologies that may be included as part of a remedy.

CERCLA Section 121(b), 42 U.S.C. Section 9621(b), establishes a preference for remedial actions which include treatment that permanently and significantly reduces the toxicity, mobility, or volume of contaminants.

For the Site-wide Alternatives, SW-1 and SW-2, no treatment would be performed, so no reduction of toxicity, mobility, or volume of contaminants would occur. SW-3 would reduce mobility, toxicity, or volume if any portions of the pipeline and associated contaminated soils are found and removed, without any treatment.

For soils and sediments, Alternatives S-6 and S-7 achieve the highest reduction of toxicity, mobility, and/or volume, since all contaminated soils would be removed or stabilized. S-7 would provides the greatest reduction through treatment of the soils and sediments. S-6 would also provide this same level of reduction if recycling and/or treatment is utilized prior to disposal. Alternatives S-5, S-4A, and S-4B also provide a high level of treatment or recycling through partial removal (if it resulted in recycling) or partial stabilization. Alternatives S-4 and S-3 do not provide for treatment or recycling, but will reduce or prevent leaching of soil contaminants to groundwater. S-4 and S-5 also include capping, which will reduce the mobility of the contaminants.

For groundwater, Alternative GW-5 provides for the greatest reduction of mobility, toxicity, and volume through treatment since contamination from the center of the groundwater plume would be extracted and treated. Alternative GW-4 also provides for a reduction in mobility, toxicity, and volume through treatment. Alternative GW-3 relies on natural attenuation which provides for a reduction in toxicity and volume through natural processes, but would not involve treatment.

Short-Term Effectiveness

Short-term effectiveness addresses the period of time needed to implement the remedy and any adverse impacts that may be posed to workers, the community and the environment during construction and operation of the remedy until cleanup levels are achieved.

SW-2 would provide greater short-term effectiveness than SW-1 since the restrictions required for the Site would prevent individuals from coming in direct contact with on-site contamination. SW-3 would be effective in the short-term if investigation of the pipeline yields remaining portions that are subsequently removed to prevent any associated risk. For soils and sediments, Alternatives S-4A, S-5, and S-6 would result in an increase in truck traffic to transport the removed soil off-site, however the amount of traffic associated with Alternatives S-4A and S-5 would be much lower than that associated with Alternative S-6. Alternatives S-3, S-4, S-4B, and S-7 would have minimal impact on the surrounding community in terms of truck traffic and other construction activities. All soil/sediment alternatives are equivalent in terms of effectiveness of temporary protective measures during cleanup. It should be noted that complete removal of all materials in the four quarries, as called for in Alternative S-6, may take over four years just for the excavation of the soils and sediments, and would not provide short-term effectiveness. In addition, S-6 provides more risk for workers through materials handling, although this would be partly mitigated by safety and health practices.

None of the groundwater alternatives would have an adverse effect on the surrounding community since only minor truck traffic would occur during construction, and the discharge piping would be below ground. Alternatives GW-4 and GW-5 would not have significant impact on the surface water since NPDES requirements would be met. GW-4 and GW-5 would provide greater short-term effectiveness through treatment than GW-3, with GW-5 providing the greatest level of short-term effectiveness. Air stripper emissions might result in an increased risk if the emission controls are not adequately maintained. All of the groundwater alternatives have increased short-term effectiveness when coupled with a soil alternative, since a soil alternative would either remove a source area or prevent continued leaching of contaminants from the soil to the groundwater.

Implementability

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other governmental entities are also considered.

All of the Site-wide Alternatives, SW-1 through SW-3, are easily implementable.

For soils and sediments, all of the alternatives are implementable. The caps in alternatives S-4, S-4A, S-4B, and S-5 are implementable, as construction associated with multi-media capping is fairly routine and performed relatively often. Alternatives that call for removal of contaminated soils (Alternatives S-4A, S-5, and S-6) require excavation of contaminated media, so personal protective equipment, and specialized equipment may be required. Alternatives S-4A, S-4B, S-5, S-6, and S-7 call for dewatering the Quarry 3 ponds, and would likely require additional equipment and design. All of the alternatives are implementable without causing undue risk to the surrounding community. Stabilization called for in Alternatives S-4B and S-7 may be more difficult to implement since it may be difficult to inject a stabilization agent to the deepest portions of contamination in the quarries, and may need special equipment.

For groundwater, Alternative GW-3 is easily implementable, as no construction is required, and it is likely that existing monitoring wells could be used to monitor for natural attenuation. Alternatives GW-4 and GW-5 would require construction of a discharge line leading from the Site to the Schuylkill River or Matsunk Creek, which may require obtaining access agreements from private parties. In addition, three extraction wells would need to be installed into the center of the plume in order to implement Alternative GW-5.

Cost

Cost refers to an evaluation of the types of costs that will be incurred with respect to a particular alternative. Cost estimates for each alternative generally include the calculation of direct and indirect capital costs and the annual operation and maintenance ("O&M") costs, both calculated on a present worth basis. The evaluation was based on the Draft FS cost estimates as modified by EPA in the Addendum to the Draft FS Report. Additional evaluation and modifications by EPA, including using a multi-layer cap instead of an asphalt cap for the capping alternatives; additional costs of construction associated with back fill and soil cover; differences in off-site disposal of soil versus off-site recycling of soils; and differences in costs associated with excavation of pond sediments were included in the Addendum to the Draft FS report. Both of these documents may be found in the administrative record for the Site.

Site-wide alternatives are $230,000 for SW-2 (institutional controls) and $148,000 for SW-3 (WAL Pipeline Investigation). Soil alternatives range from $5,407,000 (S-3; Soil Cover) to $104,030,000 (S-7; Stabilization). The cost of each soil alternative increases as the degree of soil treatment increases. Costs for the groundwater alternatives range from $600,000 (GW-3; Monitored Natural Attenuation) to $7,270,000 (GW-5; Groundwater Recovery, Treatment, and Discharge). The cost of each groundwater alternative increases as the degree of groundwater treatment increases. The estimated present worth cost for the alternatives, not including the No Action alternative, may be found in Table 10.

State Acceptance

The Commonwealth of Pennsylvania has reviewed, commented, and concurred with the selected remedy described in this ROD.

Community Acceptance

Community acceptance was assessed after reviewing public comments received on the Proposed Plan and supporting documents in the administrative record. During the public comment period, the community expressed support of Site-wide alternative SW-3 (WAL pipeline investigation) and soils alternative S-5 (Quarry 3 removal and low-permeability capping). Questions on groundwater alternative GW-3 (natural attenuation) were presented during the public meeting; however, the community expressed that this alternative was acceptable provided that periodic evaluation of the results of this remedy was conducted and an alternative remedy could be implemented if natural attenuation proved ineffective.

XI. PRINCIPAL THREAT WASTES

The NCP (Section 300.430(a)(1)(iii)(A)) establishes an expectation that a treatment option be used to address principal threat wastes wherever practicable. The soils in Quarry 3 may be considered principal threat wastes as risks associated with exposure for anticipated land use (industrial worker and construction worker) are unacceptable. Increased cancer risks for the industrial worker are in the order of 1E-3 and the HI for the construction worker is 230. Therefore, the selected remedy will incorporate components which address the risks posed by these wastes. A treatment option may be practicable if the soils and sediments removed are recycled prior to disposal. In-situ treatment is not practicable due to the associated costs.

XII. SELECTED REMEDY AND PERFORMANCE STANDARDS

Summary of the Rationale for the Selected Remedy

CERCLA requires that any remedy selected to address contamination at a hazardous waste site must be protective of public health, welfare, and the environment, cost-effective, in compliance with regulatory and statutory provisions that are applicable or relevant and appropriate requirements, and consistent with the NCP to the extent practicable. CERCLA also expresses a preference for permanent solutions, for treating hazardous substances on-site, and for applying alternative or innovative technologies.

The Site-wide remedial action objectives are as follows, and have been developed to address the following Site-specific concerns:

Soil/Sediment

- Eliminate exposure to soil/sediment which presents an unacceptable risk to human health or the environment.
- Prevent contact of soil/sediment constituents with other media such as groundwater and surface water which may transport the contamination so that the transport does not create an unacceptable risk to human health or the environment.

Surface Water:

- Limit exposure of ecological receptors to contaminated surface water.

Groundwater:

- Prevent future potential exposure to ingestion of Site-related groundwater so that the exposure risk level is between 10^{-4} and 10^{-6} excess cancer risk and the hazard index is less than 1.
- Restoration of the aquifer to a beneficial use.

EPA's Selected Remedy consists of Alternatives SW-3, S-5, and GW-3, which includes removal of all contaminated soils and sediments in Quarry 3, construction of a multi-layer cap to prevent infiltration of surface water into the contaminated soils of Quarries 1, 2, and 4 and other contaminated soil areas, monitored natural attenuation of the groundwater, and further investigation of the former WAL pipeline that was located between the Alan Wood Steel facility and Quarries 1, 2, and 3 located on the Crater Resources Site.

EPA has selected these components of the remedy because they provide the best attainment of the above Remedial Action Objectives, when evaluated using the Primary Balancing Criteria.

Alternative SW-3 provides for investigation of the former WAL pipeline and would provide for protection if portions of the pipeline and associated contaminated soils are found and removed. *Alternative S-5 provides a high level of protectiveness and treatment since the main contaminant* source areas in the soils would be removed. The cost difference between installing a low permeability cap under Alternative S-4 and removing the contaminated soils and sediments from Quarry 3 and installing a low permeability cap under Alternative S-5 is $1,500,000. In addition, the removal of this major source area will enhance the Monitored Natural Attenuation selected under Alternative GW-3. The community has also expressed a preference for the removal of the contamination, versus capping in-place; Alternative S-5 would provide for removal of the source contamination where cost-effective. The source reduction actions are meant to enhance the remedial alternative chosen for containment and restoration of the aquifer by reducing the time frame for meeting the performance standards. Alternative GW-3 is protective since the surrounding community obtains drinking water from municipal water lines, and therefore no current ingestion risk from the groundwater exists. This combination of alternatives also provides for the best balance between the other balancing criteria and cost.

Description of the Selected Remedy

Following consideration of the requirements of CERCLA, a detailed analysis of the alternatives using the nine criteria set forth in the NCP, and careful review of public comments, EPA's selected remedy consists of the following key components:

1) Removal of all contaminated soils and sediment in Quarry 3: Ponds 1, 2, and 3, which are located within Quarry 3, will be dewatered and the water will be transported to an off-site disposal facility. The sediments at the bottom of the ponds will be excavated down to the bedrock layer or to the level where contaminant concentrations in the sediments are at levels protective of groundwater, human health or ecological risk-based concentrations, dewatered, and taken off-site for proper disposal or recycling. The Quarry 3 plateau area will be excavated down to the bedrock layer or to the level where the contaminant concentrations in the soils are at human health or ecological risk-based concentrations, and the soil taken off-site for proper disposal or recycling. All remaining soil areas in Quarry 3 with contaminant levels above human health or ecological risk-based concentrations will be removed and taken off-site for proper disposal or recycling. The excavated areas will then be filled with clean soil to establish a uniform grade, and graded for proper drainage.

2) Construction of a cap to prevent infiltration of surface water into the contaminated soils of Quarries 1, 2 and 4 and other contaminated soil areas: A multi-media cap consisting of a series of low-permeability clays, geotextile liners, sand drainage layers, and soil or other appropriate covers will be installed to prevent unacceptable leaching of contaminants from the soils and sediment into the groundwater. The cap will constructed in accordance with the

Commonwealth's Residual Waste Management Regulations, for final cover of Class 1 residual waste landfills, set forth at 25 Pa. Code Sections 288.234 and 288.236-237.

3) Monitored Natural Attenuation of the groundwater: Groundwater monitoring will be conducted at on-site and off-site locations, in order to sample for selected Site-related SVOCs, metals, cyanide, and VOCs that presently exceed preliminary remediation goals. Additional parameters representative of the natural attenuation process will also be included in the monitoring program. This monitoring will provide a basis to determine the rate at which natural attenuation is taking place. EPA has determined that this rate needs to be sufficient to attain the remedial goals within a fifteen (15) year time period. If, during the fifteen (15) year time period, it is evident that the rate of natural attenuation is not sufficient to attain such goals in the fifteen (15) year time frame, EPA will then seek to implement the contingent groundwater remedy, which is described in the "Selected Remedy and Performance Standards" Section of this Record of Decision.

The contingent groundwater remedy calls for groundwater recovery and treatment from the center of the groundwater plume at the Site. The purpose is to extract and treat the most highly contaminated groundwater from beneath the Site. The recovery system would pump the water near the downgradient edges of Quarries 2 and 3 using a line of recovery wells spread across the width of the plume. The groundwater would then be pumped to an on-site treatment facility to remove contaminants to specified treatment levels and the treated water would be discharged to the Schuylkill River or Matsunk Creek.

4) Further investigation of the former WAL pipeline: The pipeline runs from the former Alan Wood Steel facility to Quarries 1, 2, and 3 located on the Site. Some sections of the pipeline been removed by the Crater PRP Group and other private parties during development activities. However, the entire route of the former WAL pipeline will be fully investigated and characterized where there has not been a previous action taken, to determine the existence of any contamination along the route. Any pipeline investigation and clean-up actions which have been conducted in accordance with an EPA accepted risk driven clean-up levels are described in Section II of this ROD. Any pipeline soil areas with contaminant levels above human health or ecological risk-based concentrations will be removed and taken off-site for proper disposal or recycling. In addition, any hardened tar material from past WAL pipeline leaks will be excavated and transported to an off-site disposal facility.

5) Institutional Controls: Institutional controls will be implemented to restrict on-site soil, sediment, surface water and groundwater use and/or disturbance at the Site, except as required for implementation of the remedy, in order to reduce the potential for human exposure to contamination. Institutional controls (e.g., easements and covenants, title notices and land use restrictions through orders from or agreements with EPA) would be established in order to prevent any disturbance of the cap once installed, as well as to preclude the installation of any potable wells in the contaminated aquifer. In addition, institutional controls in connection with adjacent property owners may be required for stormwater management.

Summary of Estimated Remedy Costs

The information in the cost estimate summary table is based on the best available information regarding the anticipated scope of the selected remedy. Changes in the cost elements are likely to occur as a result of new information and data collected during the engineering design of the selected remedy. Major changes may be documented in the form of a memorandum in the Administrative Record file, an Explanation of Significant Differences ("ESD"), or a ROD amendment. This is an order-of-magnitude engineering cost estimate that is expected to be within +50 to -30 percent of the actual project cost. The estimated capital, O&M, and present worth costs for all the Alternatives are provided in Table 10. The estimated capital, O&M, and present worth costs for the selected remedy are provided in Table 11.

Expected Outcomes of the Selected Remedy

The selected remedy for the Site will allow development of this property, once the design and construction activities are complete, and the institutional controls are complied with. It is anticipated that the design and construction of the remedy would be complete within two years. Currently, there are plans to develop every portion of the Site, with the exception of Quarry 3, based upon the land development plans which have been submitted to Upper Merion Township by the various property owners. It is anticipated that this development will lead to an increase in the number of jobs available in the area, as well as an increase in the automobile traffic.

Groundwater use will be prohibited as part of the institutional controls placed on the Site by the property owners. In accordance with the Monitored Natural Attenuation Guidance, EPA has chosen a time limit of 15 years for natural attenuation to meet the remedial action objectives. If, during the 15 year time period, it is evident that natural attenuation will not meet the remedial action objectives, EPA will default to the contingent groundwater remedy.

The cleanup standards for soils and sediment are provided in Table 12. The soils and sediment standards are health risk based, and assume a 1×10^{-5} and a hazard index of 1. The groundwater standards are health risk based, and assume a 1E-6 for the extent of the plume, and 3E-5 for the center of the plume and a hazard index of 1. It should be noted that background soil and groundwater conditions may ultimately supercede some of the low inorganic cleanup standards. This issue will be determined during the Remedial Design. The cleanup standards for groundwater are provided in Table 13.

Performance Standards

Further detailed requirements and Performance Standards associated with the selected remedy are presented below.

1. The remedy will comply with all federal and state ARARs listed in Table 14.
2. Excavated soils and sediments shall be tested to determine the presence of RCRA characteristic wastes prior to disposal. All RCRA characteristic wastes shall be handled in accordance with the substantive requirements of 25 Pa. Code Chapter 262a Subchapters A (relating to hazardous waste determination and identification numbers) and B (relating to manifesting requirements for off-site shipments of hazardous wastes); 25 Pa. Code Chapter 263a (relating to transporters of hazardous wastes); and with respect to the operations at the Site generally, with the substantive requirements of 25 Pa. Code Chapter 264a, Subchapters B-D, I (in the event that hazardous waste generated as part of the remedy is managed in containers); 25 Pa. Code Chapter 264a, Subchapter J (in the event that hazardous waste is managed, treated, or stored in tanks), and 40 C.F.R. Part 268, Subpart C and Subpart E (regarding prohibitions on land disposal and prohibitions on storage of hazardous waste). If it is determined that the soils and sediments are non-hazardous, then the Pennsylvania Residual Waste Regulations pre-transport and storage requirements shall be complied with.
3. All areas impacted by the construction activities during remedy implementation shall be graded, restored and revegetated to the extent practicable in compliance with the Pennsylvania Residual Waste Regulations concerning landfill cap vegetation.
4. Wastewater generated during decontamination activities shall be properly managed in accordance with State and Federal Laws.
5. A MNA demonstration shall be provided to EPA to determine whether MNA is effective in remediating the plume to cleanup standards in Table 13 at a rate to meet the remedial goals within a 15-year time frame. The necessary monitoring shall be determined during remedial design phase and shall be provided in a Natural Attenuation Monitoring Plan approved by EPA. A sufficient number of wells shall be installed as part of the MNA. The number, location of wells, and monitoring parameters necessary to verify the performance of the remedial action will be subject to approval by EPA. Installation of additional wells may be necessary and must be in accordance with 17 Pa. Code Chapter 47. These regulations are established pursuant to the Water Well Drillers License Act, 32 P.S. § 645.1-645.13 et seq. Monitoring shall continue until such time as EPA determines that the cleanup standard for each contaminant of concern in Table 13 has been achieved.
6. Natural attenuation relies on natural processes to decontaminate contaminated groundwater. These processes include dilution, biodegradation, volatilization, adsorption, and chemical reactions with subsurface materials. During natural attenuation, monitoring of the contaminants of concern in the monitoring wells is conducted to determine if natural attenuation is decreasing the concentrations of the contaminants at an

acceptable rate, while providing sufficient protection to human health and the environment. Specifically, groundwater samples are collected and analyzed for biological and chemical indicators to confirm that contaminant biodegradation is reducing contaminant mass, mobility, and risk at an acceptable rate. Natural attenuation may remediate the groundwater dissolved plume to cleanup standards in Table13. Results of the monitoring will be used to determine if natural attenuation is decreasing the concentrations of the contaminants at an acceptable rate, while providing sufficient protection to human health and the environment. The evaluation of the monitoring will be conducted during the 5-year review of the remedy conducted by EPA. If it is demonstrated that natural attenuation cannot remediate this portion of the plume, the implementation of the contingent groundwater treatment remedy will be evaluated in accordance with performance standard 8 B) (ii) (c) below.

7. Contingent Groundwater Treatment System shall comply with the following:

A) If MNA is not found to be effective, the groundwater at the Site shall be extracted and treated in the on-site treatment facility until the cleanup standards for all contaminants of concern are achieved for twelve (12) consecutive quarters of sampling.

B) The treatment system shall reduce the contaminants in the extracted groundwater, unattended, on a continuous, 24-hour-per-day basis. The final pumping rate of the extraction wells shall be determined during remedial design. Final design criteria for the air stripper and metals precipitation treatment systems will be determined in the remedial design phase.

C) Management of waste from the operation of the treatment system (i.e. spent carbon units, flocculates) shall comply with the requirements of 25 Pa. Code Chapter 262a Subchapters A (relating to hazardous waste determination and identification numbers); B (relating to manifesting requirements for off-site shipments of hazardous wastes); 25 Pa. Code Chapter 263a (relating to transporters of hazardous wastes); and with respect to the operations at the Site generally, with the substantive requirements of 25 Pa. Code Chapter 264a, Subchapters B-D, I (in the event that hazardous waste generated as part of the remedy is managed in containers); 25 Pa. Code Chapter 264a, Subchapter J (in the event that hazardous waste is managed, treated or stored in tanks); and 40 C.F.R. Part 268 Subchapter C and E (regarding prohibitions on land disposal and prohibitions on storage of hazardous waste).

8. Maintenance and Monitoring Plan:

A) The soil and quarry caps, groundwater extraction and treatment system, Site monitoring wells, and all other remedial action components shall be operated and maintained in accordance with an Operation and Maintenance plan to be developed for this remedial action. The Operation and Maintenance plan shall ensure that all remedial action components operate within design specifications and are maintained in a manner that will achieve the Performance Standards. The Operation and Maintenance plan shall be updated from time-to-time as may be necessary to address additions and changes to the remedial action components.

B) A long-term groundwater monitoring program shall be implemented to evaluate the effectiveness of the MNA and contingent treatment system, and other remedial action components in reducing contamination in the groundwater to achieve the Performance Standards. The long-term groundwater monitoring program will provide for the sampling and analysis of groundwater from Site monitoring, the maintenance of Site monitoring wells, and for, among other things, the following:

(i) The influent and effluent from the treatment facility shall be sampled a minimum of once per month and analyzed for each contaminant for which a Performance Standard will be established consistent with the law.

(ii) Sampling from and operation/maintenance of the monitoring wells and groundwater extraction/treatment system shall continue until such time when EPA, in consultation with PADEP, determines that groundwater treatment is no longer necessary as set forth herein.

(a) EPA, in consultation with PADEP, shall determine whether the Performance Standard for each contaminant for which a Performance Standard has been provided in Table 13, has been achieved throughout the entire area of groundwater contamination. Following any such determination, the monitoring wells shall continue to be sampled for twelve (12) consecutive quarters (the "Confirmation Period").

(b) If any contaminant is detected in groundwater at a concentration above the Performance Standard at any time during the Confirmation Period, the Confirmation Period shall end and sampling and operation/maintenance of the monitoring wells and extraction/treatment system shall continue. EPA, in consultation with PADEP, shall again determine whether the Performance Standard for each contaminant for which a Performance Standard has been provided in Table 13, has been achieved throughout the entire area of groundwater contamination as described in Paragraph (ii)(a), above.

(c) If EPA, in consultation with PADEP, determines at the close of the Confirmation Period that no Table 13 contaminant has been detected in groundwater at a concentration above the Performance Standard at any time during the Confirmation Period, the extraction/treatment system shall be shut down. Annual monitoring of the groundwater shall continue for five years after the groundwater extraction/treatment system is shutdown. If, subsequent to an extraction/treatment system shutdown, annual monitoring shows that any Table 13 contaminant is detected in groundwater at a concentration above the Performance Standard, the extraction/treatment system shall be restarted and operated/maintained. EPA, in consultation with PADEP, shall again determine whether the Performance Standard for each contaminant for which a Performance Standard has been provided in Table 13, has been achieved throughout the entire area of groundwater contamination as described in Paragraph (ii)(a), above.

(d) The extraction/treatment and monitoring system may be modified, as warranted by performance data during operation, to achieve Performance Standards. These modifications may include alternate pumping of extraction well(s) and/or the addition or elimination of certain extraction wells.

(iii) Existing pumping and/or monitoring wells which EPA determines during long-term monitoring to serve no useful purpose shall be properly plugged and abandoned consistent with PADEP's Public Water Supply Manual, Part II, Section 3.3.5.11. Wells which EPA determines are necessary for use during the long-term monitoring program will not be plugged.

9. Statutory reviews under Section 121(c) of CERCLA shall be conducted as long as hazardous substances, pollutants, or contaminants remain on-site within the meaning of that section. Such reviews shall be conducted in accordance with "Structure and Components of Five-Year Reviews" (OSWER Directives 9355.7-02, May 23, 1991 and 9355.7-02A, July 26, 1994).

10. Institutional Controls - Institutional controls shall be implemented to protect the integrity of the soil cap and the groundwater treatment system during implementation of the remedial action and operation and maintenance. At a minimum, these controls shall ensure that no construction, excavation, or regrading takes place in these areas except as approved by EPA.

11. Structural stability of open excavations shall be maintained with temporary shoring or engineering measures as appropriate. Air monitoring shall be conducted during excavations to ensure safety of Site workers and residents living in the vicinity of the Site.

12. Erosion and sediment ("E&S") controls and temporary covers will be installed to protect exposed soil from the effects of weather consistent with PADEP's Bureau of Soil and Water Conservation Erosion and Sediment Pollution Control Manual and the Montgomery County Soils Conservation policy. Erosion potential shall be minimized. Further controls in the form of Site grading to improve land grades, cover soils, vegetation, and drainage channels to reduce erosion potential from surface runoff may be required to minimize erosion. Contaminated soils shall be prevented from being washed into on-site surface water and adjacent uncontaminated and uncontrolled wetland areas during remedial action implementation. The extent of erosion control necessary will be determined by EPA, in consultation with the PADEP, during the remedial design phase.

13. Post-excavation sampling will be performed after the excavations are completed. Post-excavation samples will be obtained from the base and the sidewalls of the excavation to ensure that contamination is not present above the soil and sediment cleanup Performance Standards specified in Table 12. The frequency and location shall be determined during the RD.

14. For all excavation areas, the excavation will be backfilled using clean soil. Clean borrow material will be brought in to restore the excavation to proximate original grade. Backfilling will be performed, and the material will be compacted to minimize the potential for subsidence. The excavation area shall be covered with a layer of cover soil and revegetated with native plant material until a viable cover is established. The contents of "Office of the Federal Executive; Guidance for Presidential Memorandum on Environmentally and Economically Beneficial Landscape Practices on Federal Landscaped Grounds," 60 Fed. Reg. 40837 (August 10, 1995) shall be considered in implementing any landscaping at the Site.
15. With respect to the Quarry 3, pipeline, and swale areas, if any contaminant is detected in the post-excavation samples at levels above any of the soil cleanup Performance Standards listed in Table 12, additional soil will be removed from the excavation area and new samples obtained and analyzed. Excavation and sampling activities will continue until the results indicate that the soils do not contain contaminants of concern above any of the Performance Standards.
16 A background analysis of soil and groundwater shall be conducted during the remedial design phase to further determine if any of the inorganic contaminants of concern are background or Site-related.
17. A low permeability cover system will be designed and installed to prevent human and ecological exposures to contaminated soil and to minimize infiltration and resulting organics and metals leaching into the groundwater at Quarries 1, 2 and 4 and other contaminated soil areas. The cap will be designed and installed in accordance with 25 Pa. Code Chapter 288; cover requirements for Class 1 landfills. The exact design of the cap may be modified during the design to address Site-specific features and land uses. However, the cap must be installed in accordance with a schedule to be approved by the EPA. EPA will not accept delays in cap installation pending future Site uses. Final determination of the materials to be used for the cap will be determined during the design. Routine maintenance and repair of the cap will be required to ensure its long-term effectiveness.
18. The disposal of any contaminated soils and sediment that exhibit a characteristic of hazardous waste shall comply with 40 CFR Part 268 (RCRA Land Disposal Restrictions).

XIII. STATUTORY DETERMINATIONS

Under section 121 of CERCLA and the NCP, the lead agency must select remedies that are protective of human health and the environment, comply with applicable or relevant and appropriate requirements (unless a statutory waiver is justified), are cost-effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ treatment that permanently and significantly reduces the volume, toxicity, or mobility of hazardous wastes as a principal element. The following sections discuss how the selected remedy meets these statutory requirements.

Protection of Human Health and the Environment

The Site soils, and sediments currently pose an unacceptable direct contact risk to human health and the environment. With respect to groundwater, the Site is currently protective because nobody is using groundwater as drinking water.

EPA's Selected Remedy for the Site, which includes removal of all contaminated soils and sediments in Quarry 3, construction of a multi-layer cap to prevent direct contact and infiltration of surface water into the contaminated soils of Quarries 1, 2, and 4 and other contaminated soil areas, Institutional Controls, and further investigation of the former waste ammonia liquor pipeline that was located between the Alan Wood Steel facility and the Crater Resources Site, will adequately protect human health and the environment. The exposure levels associated with the Site soils and sediments will be reduced to protective ARAR levels or within EPA's generally accepted risk range of 10^{-4} to 10^{-6} for carcinogenic risk and below a Hazard Index of 1. In addition, the contingent groundwater remedy will adequately protect human health and the environment.

The exposure levels associated with the groundwater will be addressed through monitored natural attenuation of the groundwater, with a contingent pump and treat remedy if the cleanup standards are not attained. The exposure levels associated with the groundwater will be reduced to protective ARAR levels or within EPA's generally accepted risk range of 10^{-4} to 10^{-6} for carcinogenic risk and below a Hazard Index of 1.

There are no short-term threats associated with the revised remedy that cannot be readily controlled. In addition, no adverse cross-media impacts are expected from the revised remedy.

Compliance with and Attainment of Applicable or Relevant and Appropriate Requirements

The remedy will comply with all applicable or relevant and appropriate chemical-specific, location-specific and action-specific ARARs. Table 14 provides a list of and a description of all the ARARs and To Be Considered ("TBCs") for the Site.

Cost-effectiveness

In EPA's judgement, the selected remedy is the most cost-effective alternative considered. The remedy provides the best overall protection in proportion to cost, and meets all other requirements of CERCLA. Section 300.430 (f)(1)(ii)(D) of the NCP requires EPA to evaluate the cost-effectiveness by comparing all of the alternatives which meet the threshold criteria, overall protection of human health and the environment and the environment and compliance with ARARs, against three additional balancing criteria: long-term effectiveness and permanence; reduction of toxicity, mobility or volume through treatment; and, short-term effectiveness. The estimated present worth cost for the revised remedy presented in this ROD Amendment is $9,750,000.

Utilization of Permanent Solutions and Alternative Treatment Technologies to the Maximum Extent Practicable

EPA has determined that the selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized while providing the best balance among other evaluation criteria. Of those alternatives that are protective of human health and the environment and comply with ARARs, EPA has determined that the selected remedy is the most efficient and effective alternative when evaluated using the five balancing criteria, while also considering (1) the statutory preference for treatment as a principal element, (2) the bias against off-site treatment and disposal, (3) state and community acceptance.

The selected remedy satisfies the criteria for permanent solutions through soil and sediment removal in the Quarry 3 and pipeline source areas. In addition, the community has expressed a preference for removal of the source areas. The remedy satisfies the criteria for long-term effectiveness by monitoring and remediating the groundwater, as well as long-term monitoring of the cap's effectiveness. The capping of Quarry 1, 2, and 4, and other contaminated areas provides the best balance of tradeoffs, with respect to the other alternatives evaluated, while providing a reduction in mobility of the contaminants. Treatment of the contaminated soils and sediment was not selected due to it not being cost-effective, when the relative benefit of the associated risk reduction was compared to the increased cost..

The remedy does not present short-term risks different from the other treatment technologies. There are no special implementability issues that sets the selected remedy apart from any of the other alternatives evaluated.

Preference for Treatment as a Principal Element

The remedy contains a contingent groundwater treatment component, which will treat the contaminated groundwater through extraction, treatment and discharge, if MNA is found to be not effective. Treatment of the contaminated soils and sediment was not selected due to it not being cost-effective. The costs to treat the contaminated soils and sediments was significantly higher than capping due the depth at which the contaminates soils and sediments are found on-site. However, the soils and sediments, which are removes from Quarry 3, may be recycled prior to disposal. In addition, the contingent groundwater remedy contains a treatment component.

By utilizing treatment, the statutory preference for remedies that employ treatment as a principal element is satisfied.

Five -Year Review Requirements

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within five years after initiation of the remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

XIV. DOCUMENTATION OF SIGNIFICANT CHANGES

The Proposed Plan identifying EPA's preferred alternative for the Site was released for comment on June 16, 2000. During the public comment period, EPA received numerous comments from the public regarding EPA's Proposed Remedy. These comments are presented in detail in Part III of this ROD, the Responsiveness Summary. Although EPA has not made any significant changes with regards to the Proposed Plan, the following changes have been made:

The Feasibility Study called for the backfilling and capping of Quarry 3 under Alternative S-5, after the oils and sediments have been removed. EPA's Proposed Plan stated that the excavated areas would be backfilled with clean soil and graded for proper drainage; not the complete backfilling and capping of Quarry 3. However, the costs presented in the Proposed Plan for Alternative S-5 followed the description presented in the Feasibility Study. EPA has recalculated the costs associated with this alternative, which are described in Section XII (Selected Remedy). These revised cost for this alternative is $9,002,000; the cost presented in the Proposed Plan was $11,954,000.

The proposed Plan called for the investigation of the former WAL pipeline. However, additional information was received and reviewed after the development of the Proposed Plan concerning recent pipeline investigations and removals which have occurred. EPA has reviewed and accepted this work, as noted in Section II of the ROD.

PART III

RESPONSIVENESS SUMMARY FOR THE PROPOSED REMEDIAL ACTION PLAN

AT THE

CRATER RESOURCES SUPERFUND SITE

Upper Merion Township, PA

Public Comment Period: June 16, 2000 - August 15, 2000

RESPONSIVENESS SUMMARY
CRATER RESOURCES SITE
COMMENTS ON THE PROPOSED PLAN

This Community Relations Responsiveness Summary is divided into the following sections:

Responses--Part One: This section provides a summary of the commenters' major issues and concerns, and expressly acknowledges and responds to those raised by the local community at the public meeting held by EPA on June 27, 2000. "Local community" here means those individuals who have identified themselves as living in the immediate vicinity of a Superfund site, and or their elected officials, and are potentially threatened from a health or environmental standpoint. These may include local homeowners, businesses, the municipality, and potentially responsible parties.

Responses--Part Two: This section provides a comprehensive response to all significant written comments received by EPA. Where necessary, this section elaborates with technical detail on answers covered in Part One.

EPA's responses include clarification of the proposed remedy, and where appropriate, policy issues. It should be noted that the comments on the Proposed Plan have been considered and included in the Record of Decision where appropriate.

Any points of conflict or ambiguity between information provided in Parts One and Two of this Responsiveness Summary will be resolved in favor of the detailed technical and legal presentation contained in Part Two.

Part 1 - Comments from Crater Resources Public Meeting

Questions Regarding the Pipeline, Tarry Materials and Extent of Contamination

Comment: In reference to the tar cleanup, have any conditions been set for how cleaned up this will be?

Response: Yes. Tar will be removed and disposed off-site or capped in accordance with the selected remedy. Contaminants associated with the tar will be cleaned up to the standards set forth in Table 12.

Comment: What are EPA's plans for investigating the areas of coal tar around the Site. Were surface samples taken just along the pipeline or throughout the Site? Since coal tar has been found throughout the Site, how can EPA ensure that it will find all the contamination?

Response: A thorough investigation of the areas of coal tar will be conducted during the remedial design. If additional contamination is discovered at the Site, it would either be removed or capped.

Comment: How can I get my samples of coal tar tested?

Response: The RI, which is part of the Administrative Record, discusses the results of samples taken from the Site. Samples are collected in accordance with strict collection and analytical procedures to ensure their integrity. Samples collected by private citizens cannot be analyzed by EPA for use in the Site evaluation. EPA reminds the community that the Site is private property and entering such property without the proper consent from the property owners is trespassing.

Comment: How have other sites dealt with remediation of coal tar?

Response: Remediation of coal tar has been accomplished by various alternatives including removal and thermal desorption. Various alternatives are evaluated and screened during the FS process and those that are shown to be technically feasible, implementable, and cost effective are selected for further detailed evaluation as potential remedial alternatives. Some of the variables which influence the practicality of alternatives are the quantity of waste and the chemical composition of the waste. The final remedy for this Site was selected based on an evaluation of all the alternatives against the nine criteria set forth in the NCP, and more fully described in the text of the ROD.

Comment: Near the new bridge near Flint Hill Road, there is an obvious smell that should be investigated.

Response: This area is the former location of pipeline that had been cut. The potential responsible parties removed the resulting soil contamination to the satisfaction of EPA. As described in the ROD, the areas where there may still be sections of the pipeline remaining will be further investigated to determine if there is more contamination in that general area.

Comment: After a storm last fall, the smell was very evident. The roads were closed, and men wearing metallic suits investigated the area. Why?

Response: EPA is not familiar with that incident.

Comment: Does EPA know for certain the locations of the pipeline and any ruptures?

Response: The location of the pipeline was delineated during the RI. However, the locations of all past ruptures were not identified. Therefore, the ROD calls for further investigation to identify, delineate, and remediate these areas.

Comment: How long did Liberty work on the area of the ruptured pipeline before EPA was contacted?

Response: Liberty notified EPA prior to conducting any work on the ruptured pipeline.

Comment: Where did Liberty transport the contaminated soils it removed from around the ruptured pipeline?

Response: The soil from removal activities from the "Pink Parcel" in 1998 was taken to an approved facility after the wastes were sampled. The soils from the removal from the "Yellow Parcel" conducted earlier this year are still being stockpiled on-site (on the Yellow Parcel) awaiting disposal. These materials are on a plastic liner and covered with plastic.

Comment: The residents on Philadelphia Avenue and Crooked Lane get water in their basements. Should they be concerned about contaminants in that water?

Response: EPA has no information that this water is contaminated from the Site.

Comment: How far from the Site has sampling occurred?

Response: In addition to the sampling conducted in and around the immediate quarry areas, soil sampling has occurred along the pipeline route and in the swale area, as further described in the ROD. In addition, ground water was sampled as far as the SmithKline Beecham property.

Comment: Is our area safe? The cancer rate in our community seems to be rising.

Response: From a qualitative standpoint, EPA cannot answer this question. However, EPA can say that since the residents in the community use water from the Upper Merion Reservoir, they are not drinking groundwater that is affected by the Site. Based on the information developed during the RI/FS and in the administrative record, EPA has selected a remedy it believes will be protective of human health and the environment. We also note that the Agency for Toxic Substance and Disease Registry ("ATSDR") will begin investigating possible health risks in connection with the Site this fall, in response to concerns.

Comment: Were traces of contaminants found in the local reservoir?

Response: Yes, but only at trace amounts. The ground water at the Site flows in the direction of the Schuylkill River, and not towards the reservoir.

Comment: If contamination traveled as far as the reservoir, could it be traveling through our neighborhoods?

Response: EPA conducted a ground water survey in 1979 in order to identify possible sources of contamination threatening the Upper Merion Reservoir. The contamination which was found began the investigative process in the area, but it was not directly linked to the Site. There is no indication that the surficial contamination is migrating from the Site. The ground water plume will continue to be monitored to ensure natural attenuation is indeed occurring.

Comment: Is ATSDR's first report available?

Response: Yes, it is entitled "Preliminary Public Health Assessment for Crater

Resources," dated April 24, 1995. It is available for review in the Administrative Record for the Site, located at the Upper Merion Township library.

Comment: The owners should immediately fence the Site and post signs to prevent trespassing.

Response: EPA has only recently become aware of the amount of trespassing that is occurring on this private property and is currently working with the property owners to restrict access to the Site by fencing the property and posting signs at the property in the near future.

Comment: Is it the responsibility of the current property owners to notify EPA if additional environmental issues arise?

Response: Yes, both the Superfund Statute (CERCLA), 42 U.S.C. §§ 9601-9675, and any remediation agreements between the owners and EPA require such notice.

Comment: Is the dust on the Site contaminated because of vehicular traffic on-site?

Response: Any dust currently generated by vehicular traffic at the Site is expected to be only minimally contaminated, because the contamination at the Site is in the surface and subsurface soils in the quarries. In addition, the remedial action will contain measures to minimize the generation of fugitive dust during construction in the quarries.

Comment: Has the contamination in the quarry migrated through the soils?

Response: Yes, groundwater contamination has resulted from leaching of contaminants in soils to the groundwater, as more fully described in the Decision Summary in the ROD.

The Remedy

Comment: Why did EPA choose natural attenuation instead of groundwater treatment?

Response: Based on computer modeling of the plume, EPA believes that removal or capping of the source areas will prevent further contamination of the groundwater, and will allow the plume to clean itself in 5 to 10 years. During that time, the groundwater will be monitored. If it is determined that natural attenuation is not an effective remedy, EPA will consider other treatment options, as recognized in the ROD.

Comment: Who is responsible for cleaning up the Site?

Response: CERCLA requires that the parties who were responsible for the disposal of the contaminants at the Site are responsible for cleaning up the Site. Responsible parties include current owners or operators and past owners or operators during the time of disposal of hazardous substances. (See CERCLA, 42 U.S.C. § 9607(a)). EPA intends to negotiate an agreement with these parties to implement the remedy. EPA will oversee their actions. If an agreement cannot be reached, EPA will consider other options.

Comment: Is the low-permeability cap going to be a parking lot?

Response: The cap will be required to meet PADEP's residual waste cap requirements. An asphalt cap could be evaluated during the remedial design ("RD") phase and the area could ultimately be used as a parking lot. However, the lot would have to meet the residual waste cap requirements and standards set forth in the ROD.

Comment: How will EPA decide how to construct the proposed remedy, especially the access roads? How much truck traffic will be necessary for this cleanup?

Response: Decisions regarding construction of the remedy, including any necessary access roads and the number of vehicles necessary to perform the capping and removal activities, will be evaluated during the remedial design phase. During the design phase, the best ways to carry out the plan are studied, evaluated, and determined.

Comment: How can we comment on a plan when the whole situation is not known?

Response: The Proposed Plan calls for cleanup of the quarries and additional investigation of the pipeline, with the possibility of future remediation of the pipeline, if necessary. The only uncertainties which exist are where additional pipeline remediation will be required. However, the action required to be taken has been identified. It is consistent with EPA guidance for EPA to select certain remedies, while at the same time to require additional investigation. EPA plans on a continuing dialogue with the public, including notice before each critical phase and opportunity for discussion.

Construction by Property Owners

Comment: Who is responsible for construction on the Site? Why would construction be allowed on a Site with environmental problems?

Response: Because the Site is private property, EPA can not regulate or restrict construction at the Site. Any development during or after the remedy is regulated by the Township. However, due to public health and environmental concerns, the property owners must continue to work with the Agency to address these issues. EPA believes that it is in the best interest of future developers and property owners to work with EPA to ensure that construction plans do not interfere or are inconsistent with EPA's selected remedy. EPA will endeavor to keep the Township informed of environmental activities at the Site.

Comment: In regard to plans for development of the Site, how accurate is EPA's plan of where Quarry 1 ends?

Response: EPA has performed geoprobe studies and reviews of historical photographs to determine the locations of the quarries, and is satisfied with the accuracy of this information. Builders on the Site are aware of these quarry boundaries and will continue to work with EPA to ensure that such development does not interfere with the implementation of the remedy at the Site.

Part 2 - Crater Resources Written Comments by Commenter

<u>Comments from Environmental Resources Management on behalf of Beazer East, Inc., Keystone Coke Company, and Vesper Corporation, dated August 14, 2000:</u>

Comment: Comments submitted pertain to the portions of the Proposed Plan dealing with the route of the WAL pipeline. The Proposed Plan indicates that portions of the pipeline have been remediated but that other areas remain that have not been investigated or remediated. The PRPs have previously stated that the pipeline portions beyond Renaissance Boulevard should not be part of the Site, and in fact, the Keystone and Flint Hill portions of the pipeline have been remediated. The comment is asking for EPA to review the technical merits of the Act 2 final report for the pipeline on the Keystone parcel and the Flint Hill Road excavation report. These areas have been remediated and approved by PADEP; however, these areas have been designated in the Proposed Plan for additional investigation. These areas should not be included and burdened under the ROD because they have been shown to be safe. EPA should clarify this issue before the ROD.

Response: EPA acknowledges that the Keystone parcel and Flint Hill Road sections of the pipeline have been investigated and remediated according to PADEP Act 2 Statewide Health Standards. EPA has reviewed the reports associated with these actions, and accepts the work as submitted for the these parcels. Confirmation sampling indicates that the residual soils meet PADEP Act 2 standards. Alternative SW-3 includes an evaluation of the entire length of the WAL pipeline. Since CERCLA defines "Site" to include all areas where contamination is located, EPA must confirm that all remaining sections of the pipeline path from its origin to its ultimate end point at the Crater Site present no unacceptable risk. Therefore, additional investigation along the entire pipeline route is included in the remedy.

Comments from local citizens:

Comment: Will areas of hardened WAL be remediated?

Response: Yes. Areas of hardened WAL will be addressed in the source control portions of the remedy. In areas subject to soil removal (i.e., Quarry 3), the hardened WAL will be removed and disposed in an approved facility. The other source areas will be capped. In addition, further investigation of the pipeline route and other affected areas is required in the ROD. The remedial design will include the remediation of any hardened WAL in these areas.

Comment: Is there a threat with water which is drawn from a well on Gulph Mills Golf Course for watering the course?

Response: No. The risk assessment scenario that most closely resembles potential exposure to well water used at the golf course for watering is the current industrial worker exposed to groundwater (center of plume) via dermal contact. The increased cancer risk is 3.53E-07 and the increased non-carcinogenic risk (hazard index) is 0.59. Both of these values are within EPA's acceptable limits.

Comments from United States Department of the Interior, July 20, 2000

Comment: Despite the presence of ecologically attractive habitats on-site and against the recommendations of BTAG, EPA accepted minimal evaluation of ecological risk. USDI feels that site-specific risk evaluation should have occurred given the diversity of occupied and unoccupied fish and wildlife habitats within the Site. As is, the preferred remedy is based on risk to human health and may not provide adequate protection to ecological receptors.

Response: Review of the planned future use for the Site indicates that nearly the entire Site will be developed with into a commercial office complex (i.e. office buildings, roadways, and parking lots). The only potential exception to this is Quarry 3, where the contaminated soils and sediments will be excavated to bedrock or to risk-based standards developed during the Human Health Risk Assessment, and the excavated areas will be backfilled and graded for drainage. However, this area may be subject to development in the future. When considering the remedial alternatives and evaluating appropriate responses, EPA considered the recovery potential of the affected ecological receptors. Given the future Site use scenarios (development into an office complex), EPA determined that the recovery potential was minimal and the scope of the risk assessment was considered to be acceptable and appropriate.

Comment: EPA should identify and mandate use of ecologically relevant and protective sediment/soil clean-up criteria in all areas requiring sediment/soil excavation (Quarry 3 and WAL pipeline corridor).

Response: Please refer to the previous response.

Comment: EPA should clearly define "affected area." USDI recommends that it include all areas within the physical boundaries of Quarries 1, 2, and 4 and the drainage swales where sediment samples exceeded ecological criteria (SS1, SS2, and SS3).

Response: The "other affected areas" include the drainage swales including the locations of samples SS-1, SS-2 and SS-3. The remedy requires further delineation of the extent of contamination in these areas during the remedial design. The physical boundaries of Quarries 1, 2, and 4 are not considered "other affected areas" for the purposes of additional investigation into the extent of contamination. These boundaries are known and the quarries will be covered by the cap.

Comment: EPA should identify all wetland impacts resulting from the proposed remedy and include wetlands regulations as location-specific ARARs. At least 2.5 acres of wetlands are present on-site. Wetlands will be affected by remedial actions in Quarry 3, Quarry 4, along the WAL pipeline corridor, and in the drainage swale between Quarries 3 and 4. Compensatory mitigation must be provided for all wetland impacts at commonly applied replacement ratios.

Response: A wetland delineation was conducted in April, 1999, as described in ERM's RI Addendum dated March 31, 2000, which is available for review in the Administrative Record for the Site. The remedy and the remedial design will include an evaluation of wetlands and appropriate mitigation. EPA has identified Pennsylvania's Wetland Regulations as an ARAR, which must be complied with during the construction of the remedy.

Comment: EPA should identify the soil depth requirement for the fill and cap. The soil cover cap should contain at least 2 feet of clean soil or some additional physically confining layer to prevent exposure within the biologically active zone.

Response: The remedy specifies a cap which complies with PADEP's residual waste regulations. The final cover requirements within these regulations include a layer of cover soil at least two (2) feet thick. This will prevent exposure within the biologically active zone.

Comment: EPA should identify all terrestrial habitat impacts and adequately replace the ecological value thereof. Approximately 12 acres of upland habitat, including significant acreage of mature mixed deciduous forest, will be destroyed by completion of the remedy. At a minimum, all capped areas should be graded and seeded to a native grassland habitat.

Response: The cap design includes grading, placement of topsoil, and reseeding/ revegetation. EPA Region III recognizes the value of ecosystem restoration efforts, and incorporates these concepts wherever practicable during remedial design activities. However, there is no regulatory basis under CERCLA to mandate the precise plantings recommended by the commentor. Most plantings will be destroyed during the future development of the Site. The USDI and EPA focus should be on the areas for which there will be a long-term benefit from the suggested plantings. EPA will continue to provide USDI with an opportunity to comment and participate on the design.

Comment: EPA should review sampling results from Areas 5 and 6 and the former WAL pipeline removal actions. Application of the criteria listed above should be applied to these areas, and any areas exceeding such clean-up criteria should be capped.

Response: EPA has reviewed the data relating to these areas. The ROD specifies those areas requiring additional investigation and/or remediation.

<u>Comments from Connie Williams, State Representative, 149th Legislative District, dated July 5, 2000</u>

Comment: Why, if the Site has been listed on the NPL since October 1992, is EPA only now concerned about the extent of trespassing on the property? (* meeting commentary

June 27, 2000)

Response: EPA did not have a continuous presence at the Site, and was not previously aware of the extent of trespassing on the Site. This issue was never raised nor discussed in previous meetings or interviews with the Potentially Responsible Parties ("PRPs"), landowners, local residents and officials, or contractors working at the Site. Now that EPA is aware of the extent of the trespassing, we are working with the property owners to address this problem.

Comment: Who should have been responsible for institutional controls and for posting the property during this time period?

Response: The landowner and the PRPs are responsible for implementing the access restrictions and for posting of the property. During the RI/FS process, had the problem been identified, EPA would have required the landowners and PRPs to implement some measures to restrict access to the site (i.e. fencing, warning signs, etc.).

Comment: Why has it taken so long from the first groundwater monitoring survey in 1979, to its listing in 1992 on the NPL, until its 1994 Remedial Investigations/Feasibility Study and its completion in January 1999? And now only 22 years after the Site was closed by Alan Wood Steel, is remediation being discussed?

Response: In the early 1980's, EPA was listing many new sites on the NPL; approximately 2500 in our Region. Section 104 of CERCLA, 42 U.S.C. § 9604, and the NCP, 40 CFR Part 300, have certain procedures that EPA must follow with regard to the investigation and remediation of Superfund sites. These procedures require extensive study and evaluation which can result in a lengthy time frame from NPL listing to actual remediation of the Site. The length of time between the listing on the NPL and the initiation of the Remedial Investigation/Feasibility Study was exacerbated by the lengthy process of identifying the PRPs, negotiating an agreement with the PRPs for the performance of a Remedial Investigation/Feasibility Study, and the actual performance of this study at the Site. The complexity of the Site's ownership, as well as the nature and extent of contamination, further complicated the timeline for the performance of the Remedial Investigation/Feasibility Study.

Comment: I have read your "Summary of Site Risks" - can you please explain what "the greatest maximum hazard index is to a child resident potentially using groundwater" means, or "a resident ingesting contaminated soils from Quarry 3?" Is a risk-based clean-up intended? Would mosquitoes or flies transmit contaminants?

Response: EPA's benchmark for non-carcinogenic risks is a Hazard Index ("HI") of less than 1 for a particular receptor population and exposure route associated with an impacted media. Each receptor population (i.e. child, adult, worker) has specific EPA recommended standard values for daily intake calculations, which are used to calculate HIs. The standard value is based on the media (i.e. soil, groundwater) and the route of entry (i.e. ingestion, breathing). Using these standard values and the known level of contamination detected, an HI is calculated for different scenarios. The non-carcinogenic risk is then evaluated for the Site based on these HI values.

The greatest maximum hazard index to a child resident potentially using groundwater means the highest non-cancer risk number that EPA calculated for a child who might drink the water on a regular basis.

A resident ingesting contaminated soils from Quarry 3 means a person living near Quarry 3 (hypothetical), who would have frequent contact with the soil in that area.

The selected remedy is intended to achieve a human health risk-based cleanup of the Site.

Mosquitoes or flies are not known to transmit the contaminants associated with the Site.

Comment: My constituents in Hughes Park are very concerned about the storm water runoff from the Site that they experience with each severe rain. Since this is not addressed in your report, please advise as to the storm water and erosion/sedimentation controls that will be instituted, their placement at the Site, and the intended duration of their placement there?

Response: These issues will be investigated during the RD of the remedy. EPA will ensure that the storm water and erosion/sedimentation controls incorporated into the RD will be performed during the remedial action ("RA"). This work will be conducted either by EPA or the PRPs under EPA oversight.

Comment: What monitoring will the EPA and the potentially responsible parties conduct on-site during the construction period, should this project be approved?

Response: Air monitoring, surface water monitoring and monitoring of the erosion and sedimentation controls will be required during the RA. During the implementation of the remedial design ("RD"), EPA will provide oversight of the work, to ensure compliance with the RD standards.

Comment: What monitoring will the EPA and the potentially responsible parties conduct should the project be completed? Mr. O'Neill states he has a perfect record of compliance with EPA regulations and standards in his other projects. Is this record available for public inspection?

Response: The RA includes long-term monitored natural attenuation with groundwater sampling for a specific duration until it is demonstrated that the groundwater has attained the performance standards set forth in this Record of Decision. In addition, the capped areas will require regular inspection, once construction has been completed. EPA will ensure that proper monitoring of the performance of the remedy will be conducted.

EPA files do not contain information on Mr. O'Neill's compliance record. For compliance information, contact either Mr. O'Neill directly or the Pennsylvania Department of Environmental Protection.

Comment: Can Upper Merion Township withdraw approval of construction if remediation does not proceed as expected?

Response: The Township has exclusive legal authority over construction approvals. Inquiries on this particular matter should be directed to the Township.

Comments from Liberty Property Trust, August 14, 2000:

Comment: Liberty requests acknowledgment in the ROD that Liberty's environmental work completed to date, as well as its future development plans, which were submitted to EPA, fully addresses all environmental issues of concern on the Liberty property.

Response: EPA has acknowledged the pipeline work, some of which was previously performed by Liberty. Please see Section II of the ROD. However, Liberty's future development plans must be reviewed by EPA to ensure that these plans will not adversely impact upon the selected remedy. Also, the plans, which were previously provided to EPA by Liberty do not address all the environmental issues related to their property.

Comment: The properties on Liberty's Yellow Parcel and Pink Parcel have been investigated and remediated and therefore should be excluded from the ROD.

Response: EPA acknowledges that the Liberty has been investigated and remediated its section of the pipeline according to PADEP standards. EPA has reviewed the reports associated with these actions, and accepts the pipeline removal work as submitted for the "Pink" and "Yellow" parcels. Confirmation sampling conducted by Liberty indicates that the residual soils meet PADEP Act 2 statewide health standards. Alternative SW-3 includes an evaluation of the entire length of the WAL pipeline. However, EPA must confirm that all remaining sections of the pipeline path from its origin to its ultimate end point at the Site present no unacceptable risk. Therefore, additional investigation along the entire pipeline route is included in the remedy.

Comment: The Quarry 4 area located on the Yellow Parcel does not warrant a multi-media cap. The improvements already made by Liberty and those to be made are sufficient and no additional actions are necessary. Approximately 20 to 25 feet of soils containing 10 to 30% clay have been added to Quarry 4. If EPA still intends to include in the ROD any remedial requirements, including institutional controls, beyond those already implemented by Liberty, Liberty requests a meeting to discuss the requirements.

Response: EPA has selected capping with implementation of Institutional Controls for the Quarry 4 area. While Liberty has shared its development plans for its property in the past, EPA's review of the projects were limited in that there was not, at that time, a proposed or selected remedy to use as a basis for conducting the review. Therefore, EPA has selected capping as the remedy for Quarry 4, as previously discussed in the Proposed Plan. The 2201 Renaissance Boulevard construction and 2301 Renaissance Boulevard plans (for future construction) will be evaluated by EPA during the remedial design to ensure the completeness of the remedy and compliance with the ARARs and performance standards defined in the ROD. Institutional controls are required to ensure the long-term protectiveness of the constructed remedy. EPA will continue to meet with all affected parties as the project progresses.

Comment: Concerning the Quarry 3 remediation, has EPA determined where access will be obtained for construction vehicles? Will dewatering of the ponds and exposure and excavation of the sediments cause any significant air emissions issues for residents, tenants, or construction workers working on the Yellow Parcel? What contingencies are provided in the event that remediation activities require the evacuation of nearby properties? These safety concerns should be listed in the ROD.

Response: The remedial design will address these details of the remedial action including vehicular traffic/access to the Site. The work plans for the remedial action will contain a health and safety program specifying monitoring during construction activities and contingency plans (which will evaluate any need for evacuation plans). Visible dust and odor emissions have been addressed in the ARARs section of the ROD.

Comment: Specify in the ROD how the remediation will be organized to minimize disruption of the businesses located in Renaissance Park.

Response: Every attempt will be made to minimize disruption of nearby businesses during the remedial action, will be evaluated during the RD. Procedures controlling truck traffic and all other Site operations will be put in place during the RD/RA phase and will address minimizing the impacts on these businesses.

Comment: Has the noted contamination at Area 6 been completely addressed to EPA's satisfaction? What contaminants have been identified at Area 6 and how are they going to be addressed in the ROD? Is EPA satisfied with investigation and remediation activities that have occurred in this Area to date? Why hasn't this area been subjected to the RI/FS process? If EPA is not satisfied, identify the remedial actions that will be necessary to ensure that Area 6 does not present a threat to human health or the environment.

Response: A report was submitted to EPA by Pennoni Associates (but not to PADEP), dated January 14, 2000 concerning the removal of the unsuitable materials in Area 6. PAHs and VOCs were encountered 20-22 feet below the ground surface. The actions taken in this area will be more fully evaluated during the remedial design by EPA and PADEP to determine whether the cleanup standards have been met, and whether a cap is required. This area was not identified until late in the RI/FS process. Since it contained the same Contaminants of Concern ("COCs") as found in the other areas which were investigated, it was not necessary to characterize this area more fully for the purpose of selecting a remedy.

Comment: Liberty is concerned that surficial or close-to-surface contamination may still be present on neighboring properties. EPA should require in the ROD specific identification of the locations of the tarry materials mentioned at the public meeting and remediation of such materials in and around the former pipeline route from the eastern property line to Quarries 1, 2, and 3.

Response: Additional investigation to determine the extent of contamination along the pipeline route and other affected areas is required by the ROD and will be performed as part of the remedial design.

Comments from de maximis, inc., August 2, 2000:

Comment: EPA, in a meeting on July 12, 2000, stated that asphalt capping (without a multi-media cap) is acceptable for Quarry 1 and 2, and other affected areas, so long as the asphalt is utilized as part of the land development plans and any Pennsylvania ARAR for asphalt construction is met.

Response: EPA did not make the above statement during the referenced meeting. What was stated was that asphalt would be acceptable only if it could be demonstrated that the asphalt cap would meet the State's regulatory environmental cap requirements (which are listed as an ARAR on Table 14).

Comment: Soil Alternative S-4 should be selected as the preferred remedy instead of Soil Alternative S-5. Alternative S-4 appears to provide equal or superior overall protection of human health and the environment when compared to Alternative S-5. Alternative S-4 appears to accomplish the RAOs at least as well as Alternative S-5. The additional risks of increased truck traffic, exposure to contractors, etc., may offset the benefits of removing the hazardous materials. In addition, the removal may breach the tarry layer at the pond bottoms and actually allow more contamination of the bedrock aquifer. Also, S-4 would cost over $4,000,000 less than S-5.

Response: EPA has selected Soil Alternative S-5 over Soil Alternative S-4 for several reasons. The increased carcinogenic and non-carcinogenic risks are greater for Quarry 3 soils and sediments than in soils from other areas on-site. An evaluation of the increased risks has led EPA to classify the wastes present as principal threat wastes. EPA's RIFS Guidance indicates that principal threat wastes should be removed from the Site where practical. EPA has also re-evaluated costs associated with these alternatives and estimated that Alternative S-5 present worth costs are $9,002,190 rather than $11,954,000 as presented in the Proposed Plan. The costs associated with S-5, therefore, are approximately $1,500,000 more than Alternative S-4, rather than $4,000,000 more as indicated in the written comment. Based on these costs and the presence of principal threat wastes, EPA has determined that Alternative S-5 better accomplishes the remedial action objectives of limiting exposure to soil/sediment that presents unacceptable risks to human health and the environment. EPA acknowledges that there are risks inherent with conducting remedial actions and there are short-term risks associated with the removal of contaminated materials as well as increased truck traffic. The remedial action work plans will include procedures to minimize these risks. These will include use of monitoring and personal protective equipment for workers during construction of the remedy and the implementation of procedures to assure that truck traffic operates according to local and state regulations.

Comment: The ROD should include language allowing flexibility during remedial design for land development considerations. For example, a multi-media cap may pose problems for land development and construction; whereas, an asphalt cap would allow construction and accomplish the same objectives. Also, addressing "other affected areas" would be best addressed during the remedial design phase in consideration of the most up-to-date land development plans and remedial objectives for the Site.

Response: EPA agrees that the flexibility suggested above should be reflected in the remedial design process. However, the ARARs and performance standards for the ROD must be attained. Also, as stated previously, the remedial action must be completed in a timely manner, and not be contingent on a yet to-be-scheduled development plan.

Comment: EPA should remain flexible with respect to the final cover and use of Quarry 3. As currently stated in the Proposed Plan under Alternative S-5, the excavated areas are to be filled with clean soils and graded for proper drainage. This would require 170,000 tons of soil to be transported to the Site.

Response: The Proposed Plan and this ROD do not call for the complete filling of Quarry 3, but rather filling in the excavated areas, and grading. The Feasibility Study did list the complete backfilling of Quarry 3 as a component of S-5. However, there is no environmental need to fill this Quarry in to existing grade. Also, EPA has not required any post-construction use restrictions on Quarry 3, other than those listed under the Institutional Control component of the remedy.

Comments from PADEP, September 22, 2000:

Comment: PADEP stated that if the human health risk-based cleanup standards for sediments are low enough to meet the Act 2 requirements, the Department would find this to be acceptable.

Response: Where Act 2's Statewide Health Standards for Soils provides more stringent requirements than the human health risk-based cleanup standards for the Site, EPA has incorporated these more stringent requirements as soil cleanup standards in Table 12.

Comment: PADEP stated that the issue of whether a RCRA cap would be required, would receive further study during the remedial design, and that if the waste was ultimately determined to be hazardous, then these areas must be closed pursuant to the requirements of RCRA and the federal/state hazardous waste regulations. However, in the event EPA determines that these areas do not contain hazardous waste, the Department's regulations set forth at 25 Pa. Code Chapter 288 for final cover of Class 1 residual waste landfills should be considered ARARs for the remedial action.

Response: EPA and PADEP have reviewed this issue since the issuance of the comment letter, and both agree that based upon the sampling which has been conducted at the Site, the ARAR for the cap will be the Commonwealth's Residual Waste Management regulations, for final cover of Class 1 residual waste landfills set forth at 25 Pa. Code Sections 288.234, 288.236-237, and 288.241-.244 as noted in Table 14.

Appendix A

Toxicological Profiles

A.1 Acetone

A.1.1 Non-carcinogenic Toxicity

EPA (1999b) published an oral reference dose RfD of 1.00E-01 mg/kg/day based on increased kidney and liver weights and nephrotoxicity in an oral subchronic rats study. EPA (1999b) has not published an reference concentration (RfC) or Inhalation reference dose (RfD) for acetone.

A.1.2 Carcinogenicity

EPA (1999b) classifies acetone as a cancer weight-of-evidence Group D substance (not classifiable as to carcinogenicity in humans).

A.2 Aluminum

A.2.1 Non-carcinogenic Toxicity

Aluminum is not generally regarded as an industrial poison. Inhalation of finely divided powders has been reported as a cause of pulmonary fibrosis. Aluminum in aerosols has been implicated in Alzheimer's disease. EPA (1999a) presented an oral RfD of 1.00E+00 mg/kg/day (NCEA). EPA (1999a) presented an inhalation RfD of 1.00E-03 mg/kg/day (NCEA).

A.2.2 Carcinogenicity

No oral or inhalation SFs are available for aluminum (EPA, 1997, 1999a, 1999b).

A.3 Arsenic

A.3.1 Pharmacokinetics

Several studies confirm that soluble inorganic arsenic compounds and organic arsenic compounds are almost completely (>90 percent) absorbed from the GI tract in both animals and humans (Ishinishi et al. 1986). The absorption efficiency of insoluble inorganic arsenic compounds depends on particle size and stomach pH. Initial distribution of absorbed arsenic is to the liver, kidneys, and lungs, followed by redistribution to hair, nails, teeth, bone, and skin, which are considered tissues of accumulation. Arsenic has a longer half-life in the blood of rats, compared with other animals and humans, because of firm binding to the hemoglobin in erythrocytes.

Metabolism of inorganic arsenic includes reversible oxidation-reduction so that both arsenite (valence of 3) and arsenate (valence of 5) are present in the urine of animals treated with arsenic of either valence (Ishinishi et al. 1986). Arsenite is subsequently oxidized and methylated by a saturable mechanism to form mono- or dimethylarsenate; the latter is the predominant metabolite in the urine of animals or humans. Organic arsenic compounds (arsenilic acid, cacodylic acid) are not readily converted to inorganic arsenic. Excretion of organic or inorganic arsenic is largely via the urine, but considerable species variation exists. Continuously exposed humans appear to excrete 60 to 70 percent of their daily intake of arsenate or arsenite via the urine.

A.3.2 Non-carcinogenic Toxicity

A lethal dose of arsenic trioxide in humans is 70 to 180 mg (approximately 50 to 140 mg arsenic; Ishinishi et al. 1986). Acute oral exposure of humans to high doses of arsenic produce liver swelling, skin lesions, disturbed heart function, and neurological effects. The only non-carcinogenic effects in humans clearly attributable to chronic oral exposure to arsenic are dermal hyperpigmentation and keratosis, as revealed by studies of several hundred Chinese exposed to naturally occurring arsenic in well water (Tseng 1977; Tseng et al. 1968; EPA 1999b). Similar effects were observed in persons exposed to high levels of arsenic in water in Utah and the northern part of Mexico (Cebrian et al. 1983; Southwick et al. 1983). Occupational (predominantly inhalation) exposure is also associated with neurological deficits, anemia, and cardiovascular effects (Ishinishi et al. 1986), but concomitant exposure to other chemicals cannot be ruled out. EPA (1999b) derived an RfD of 3.00E-04 mg/kg/day for chronic oral exposure, based on an NOAEL of 0.0008 mg/kg/day for skin lesions from the Chinese data. An uncertainty of 3 is applied to account for both the lack of data to preclude reproductive toxicity as a critical effect and to account for some of the uncertainty in whether the NOAEL of the critical study accounts for all sensitive individuals. The principal target organ for arsenic appears to be the skin. The nervous system and cardiovascular systems appear to be less significant target organs. Inorganic arsenic may be an essential nutrient, exerting beneficial effects on growth, health, and feed conversion efficiency (Underwood 1977). EPA (1999b) has not published an RfC or Inhalation RfD for arsenic.

A.3.3 <u>Carcinogenicity</u>

Inorganic arsenic is clearly a carcinogen in humans. Inhalation exposure is associated with increased risk of lung cancer in persons employed as smelter workers, in arsenical pesticide applicators, and in a population residing near a pesticide manufacturing plant (EPA 1999b). Oral exposure to high levels in well water is associated with increased risk of skin cancer (Tseng 1977; EPA 1999b). Extensive animal testing with various forms of arsenic given by many routes of exposure to several species, however, has not demonstrated the carcinogenicity of arsenic (International Agency for Research on Cancer [IARC] 1980). EPA (1999b) classifies inorganic arsenic in cancer weight-of-evidence Group A (human carcinogen), and recommends an oral unit risk of 0.00005 ug/L in drinking water, based on the incidence of skin cancer in the Tseng (1977) study.. EPA (1999b) published an oral SF of 1.50E+00 per mg/kg/day. EPA (1999b) notes that the uncertainties associated with the oral unit risk are considerably less than those for most carcinogens, so that the unit risk might be reduced an order of magnitude. An inhalation unit risk of 0.0043 per ug/m3, equivalent to a inhalation RfD of 1.51E+01 per mg/kg/day, was derived for inorganic arsenic from the incidence of lung cancer in occupationally exposed men (EPA 1999b).

A.4 Barium

A.5.1 <u>Non-carcinogenic Toxicity</u>

Barium is a naturally occurring alkaline earth metal that comprises approximately 0.04 percent of the earth's crust (Reeves 1986a). Acute oral toxicity was manifested by GI upset, altered cardiac performance, and transient hypertension, convulsions, and muscular paralysis. Repeated oral exposures were associated with hypertension. Occupational exposure to insoluble barium sulfate induced benign pneumoconiosis (ACGIH 1991). EPA (1999b) published a verified chronic oral RfD of 7.00E-02 mg/kg/day, based on an NOAEL of 0.21 mg/kg/day in a ten-week study in humans exposed to barium in drinking water and an uncertainty factor of 3. The uncertainty factor of 3 is assigned to the oral RfD to account for a lack of potential differences between adults and children. The critical effects seen were hypertension and the data suggested possible renal effects in animal and human studies. EPA (1997) presented a Inhalation RfD of 1.43E-04 mg/kg/day based on a fetotoxicity study in rats.

A.4.2 Carcinogenicity

EPA (1999b) considers barium as not likely to be a human carcinogen, however, the lack of adequate inhalation studies preclude EPA from classifying barium as a cancer weight-of-evidence Group D substance (not classifiable as to carcinogenicity in humans).

A.5 Benzene

A.5.1 Non-carcinogenic Toxicity

In humans, short-term inhalation exposure to benzene induced CNS effects such as drowsiness, dizziness, and headaches; long-term exposure induced anemia (ACGIH 1991). Oral dosing in animals induced hematopoietic effects (ATSDR 1995c). EPA (1999a) published an oral RfD of 3.00E-03 mg/kg/day (NCEA). EPA (1999a) presented an inhalation RfD of 1.70E-03 mg/kg/day (NCEA). The immune system, hematopoietic system, and CNS are the apparent target organs of benzene.

A.5.2 Carcinogenicity

EPA (1999b) classifies benzene in cancer weight-of-evidence Group A (human carcinogen) based on several studies of increased risk of non-lymphocytic leukemia associated with occupational exposure, supported by an increased incidence of neoplasia in rats and mice exposed by inhalation and gavage. A verified oral SF of 2.90E-02 per mg/kg/day (EPA 1999b) and an inhalation SF of 2.90E-02 per mg/kg/day are based on the increased incidence of leukemia in several occupational (inhalation exposure) studies.

A.6 Beryllium

A.6.1 Non-carcinogenic Toxicity

Beryllium has a low order of toxicity when ingested because it is poorly absorbed from the GI tract (Reeves 1986b). Occupational exposure was associated with dermatitis, acute pneumonitis, and chronic pulmonary granulomatosis (berylliosis). Berylliosis was also observed in humans living in the vicinity of a beryllium plant. Similar pulmonary effects were observed in laboratory animals subjected to inhalation exposure. A verified chronic oral RfD value of 2.00E-03 mg/kg/day (EPA 1999b) was based on small intestinal lesions in a dog dietary study and an uncertainty factor of 300 (EPA 1999b). EPA (1999a) presented an inhalation RfD of 5.70E-06 mg/kg/day (NCEA). The GI Tract, respiratory and immune system are the apparent target organs of beryllium.

A.6.2 Carcinogenicity

EPA (1999b) classifies beryllium in cancer weight-of-evidence Group B1 (probable human carcinogen) based on limited evidence of carcinogenicity in human exposed to airborne beryllium (lung cancer) and sufficient evidence of carcinogenicity in animals (lung cancer in rats and monkeys inhaling beryllium, lung tumors in rats exposed to beryllium via intratracheal instillation, and osteosarcomas in rabbits and possibly mice receiving intravenous or intramedullary injection), beryllium is reclassified from a B2 to a B1 using criteria of the 1986 Guidelines for Carcinogen Risk Assessment. The oral database is considered inadequate for the assessment of carcinogenicity. An inhalation unit risk of 0.0024 per µg/m3, equivalent to 8.4 per mg/kg/day (EPA 1997) (assuming an inhalation rate of 20 m3/day and body weight of 70 kg for humans), was derived from an occupational study.

A.7 Cadmium

A.7.1 Pharmacokinetics

Estimates of cadmium uptake by the respiratory tract range from 10 to 50 percent; uptake is greatest for fumes and small particles and least for large dust particles (Friberg et al., 1986; Goyer, 1991). GI absorption of ingested cadmium is ordinarily 5 to 8 percent, but may reach 20 percent in cases of serious dietary ion deficiency. Highest tissue levels are normally found in the kidneys followed by the liver, although levels in the liver may exceed those in the kidneys of persons suffering from cadmium-induced renal dysfunction. The half-life of cadmium in the kidneys and liver may be as long as 10-30 years. Fecal and urinary excretion of cadmium are approximately equivalent to normal humans exposed to small amounts. Urinary excretion increases markedly in humans with cadmium-induced renal disease.

A.7.2 Non-carcinogenic Toxicity

Acute inhalation exposure to fumes or particles of cadmium induces respiratory symptoms, general weakness, and, in severe cases, respiratory insufficiency, shock, and death (Friberg et al., 1986). Acute oral exposure induces GI disturbances. Chronic inhalation exposure induces pulmonary emphysema, and chronic exposure by either route consistently produces renal tubular disease in humans and laboratory animals. Proteinuria is a reliable early indicator of cadmium-induced kidney disease. The combination of pulmonary emphysema and renal tubular disease, if severe, may result in early mortality. Painful osteomalacia and osteoporosis may arise from altered metabolism of bone minerals secondary to renal damage. The combination of renal and skeletal damage is called itai-itai disease in Japan. Cadmium exposure ahs been associated with liver damage, but the liver appears to be less sensitive than the kidney. The kidney is the primary target organ of cadmium toxicity. EPA (1999b) derived chronic oral RfD values of 5.00E-04 mg/kg/day for cadmium ingested in water and 1.00E-03 g/kg/day for cadmium ingested in food (solid material), based on a toxicokinetic model that predicted NOAELs from renal cortical concentration of cadmium. The different RfD values reflect assumed differences in GI absorption of cadmium from water (5 percent) and food (2.5 percent). EPA (1999b) has not published an RfC or Inhalation RfD for cadmium.

A.7.3 Carcinogenicity

Carcinogenicity data in humans consist of several occupational studies that associate cadmium exposure with lung cancer, but concomitant exposure to other carcinogenic chemicals and smoking were not adequately controlled. Other occupational studies reported significantly increased risk of prostatic cancer, but this effect was not observed in the largest occupational study of workers exposed to high levels (Thun et al., 1985). The animal data consist of an inhalation study in rats that showed a significant increase in lung tumors, and several parenteral injection studies that produced injection site tumors. No evidence of carcinogenicity, however, was observed in seven oral studies in rats and mice. EPA (1999b) classifies cadmium a cancer weight-of-evidence Group B1 substance for inhalation exposure on the basis of limited evidence of carcinogenicity in humans and sufficient evidence in animals. The data were insufficient to classify cadmium as carcinogenic to humans exposed by the oral route. An inhalation unit risk of 0.0018 mg/m3, equivalent to 6.30E+00 per mg/kg/day, was derived from the occupational exposure study by Thun et al. (1985) assuming an inhalation rate of 20 m3/day and a body weight of 70 kg for humans.

A.8 Chloroform

A.8.1 Non-carcinogenic Toxicity

Oral or inhalation exposure of animals to chloroform was associated with liver and kidney damage (ACGIH 1991; EPA 1999b). In humans, acute inhalation exposure to high levels induced narcosis, ventricular fibrillation, and death (ACGIH 1991). Limited occupational data associated chronic exposure to chloroform with CNS depression, digestive disturbances, and enlarged livers. EPA (1999b) presented a verified chronic oral RfD of 1.00E-02 mg/kg/day based on an LOAEL for fatty cyst formation in the livers of dogs treated orally for 7.5 years and an uncertainty factor of 1,000. EPA (1999a) presented an inhalation RfD of 8.60E-05 mg/kg/day (NCEA). Target organs for the toxicity of chloroform include the liver and kidney for oral and inhalation exposure, and the blood for inhalation exposure.

A.8.2 Carcinogenicity

Chloroform is classified as a cancer weight-of-evidence Group B2 compound (probable human carcinogen), based on increased incidence of several tumor types in rats and liver tumors in mice (EPA 1999b). Human carcinogenicity data are inadequate. An oral SF of 8.10E-02 per mg/kg/day (EPA 1999b) was derived from the incidence of kidney tumors in rats treated with chloroform in drinking water for two years. An inhalation unit risk of 2.3E-05 per µg/m3, equivalent to 6.30E+00 per mg/kg/day, was based on the incidence of hepatocellular carcinomas in mice treated by gavage for 78 weeks (EPA 1999b).

A.9 Chromium

A.9.1 Non-carcinogenic Toxicity

In nature, chromium (III) predominates over chromium (VI) (Langård and Norseth 1986). Little chromium (VI) exists in biological materials, except shortly after exposure, because reduction to chromium (III) occurs rapidly. Chromium (III) is considered a nutritionally essential trace element and is considerably less toxic than chromium (VI).

No effects were observed in rats consuming 1800 mg chromium (III)/kg/day in the diet for over two years (EPA 1999b). The NOEL of 1800 mg/kg/day and an uncertainty factor of 1,000 was the basis for a verified chronic oral RfD of 1.5E+00 mg/kg/day (EPA 1999b).

A target organ was not identified for chromium (III).

Acute oral exposure of humans to high doses of chromium (VI) induced neurological effects, GI hemorrhage and fluid loss, and kidney and liver effects. Parenteral dosing of animals with chromium (VI) is selectively toxic to the kidney tubules. An NOAEL of 2.4 mg chromium (VI)/kg/day in a one-year drinking water study in rats was the basis of a verified RfD of 3.00E-03 mg/kg/day for chronic oral exposure (EPA 1999b). An uncertainty factor of 300 represents two 10-fold decreases in dose to account for both the expected interhuman and interspecies variability in the toxicity of the chemical in lieu of specific data and an additional factor of 3 to compensate for the less-than-lifetime exposure duration of the study (EPA 1999b). The kidney may be the principal target organ for repeated oral dosing with chromium (VI), but effects seen in the principal RfD study were increased levels of chromium (VI) in kidneys, livers, and femurs of test subjects.

EPA (1999b) published an inhalation RfC of 0.0004 mg/m3, equivalent to 2.86E-05 mg/kg/day, based on a BMD of 0.016 mg/m3 in a rat subchronic study. Critical effects seen were lactate dehydrogenase in bronchioalveolar lavage fluid. An uncertainty factor of 300 was also applied to the inhalation RfC based on a accounting for pharmacodyna differences not accounted for, and a 10-fold factor to account for the less than lifetime exposure and a 10-fold factor to account for variation in the human population (EPA 1988).

A.9.2 Carcinogenicity

Data were not located regarding the carcinogenicity of chromium (III). EPA (1999b) classifies chromium (VI) in cancer weight-of-evidence Group D (not classifiable regarding human carcinogenicity), via the oral route of exposure. EPA (1999b) classifies chromium (VI) in cancer weight-of-evidence Group A (human carcinogen), via inhalation exposure based on the consistent observation of increased risk of lung cancer in occupational studies of workers in chromate production or the chrome pigment industry. Parenteral dosing of animals with chromium (VI) compounds consistently induced injection-site tumors. inhalation unit risk of 0.012 per ug/m3, equivalent to 4.10E+01 per mg/kg/day (EPA 1999b), assuming humans inhale 20 m3/day and weigh 70 kg, was based on increased risk of lung cancer deaths in chromate production workers.

A.10 Cobalt

A.10.1 Non-carcinogenic Toxicity

Acute high oral or parenteral doses of cobalt in humans or animals induced myocardial degeneration often leading to mortality, erythropoiesis, enlarged thyroid, and, in animals, renal tubular degeneration (Elinder and Friberg 1986). Chronic ingestion from the consumption of beer containing high concentrations of cobalt was associated with "beer-drinkers cardiomyopathy," which includes polycythemia and goiter, as well as marked myocardial degeneration and mortality. The therapeutic use of 0.16 to 0.32 mg cobalt/kg/day in anemic, anephric dialysis patients for 12 to 32 weeks induced a significant, but reversible, rise in blood hemoglobin concentration (EPA 1992).

Occupational (inhalation and dermal) exposure was associated with allergic dermatitis, chronic interstitial pneumonitis, reversibly impaired lung function, occupational asthma, and myocardial effects (ACGIH 1991). Cobalt was determined to be the etiologic factor in hard metal disease, the syndrome of respiratory symptoms, and pneumoconiosis associated with inhalation exposure to dusts containing tungsten carbide with cobalt powder as a binder (Elinder and Friberg 1986). The lowest occupational air concentration of cobalt associated with hard metal disease was 0.003 mg cobalt/m3 (Sprince et al. 1988). It should be noted that the workers were also exposed to tungsten and sometimes to titanium, tantalum, and niobium (Elinder and Friberg 1986). Similar lung effects were seen in animals exposed to cobalt by inhalation.

The developmental toxicity of cobalt was tested in rodents treated orally with cobalt chloride (EPA 1992). Maternal effects (unspecified) were reported in rats treated with 5.4 to 21.8 mg cobalt/kg/day from gestation day 14 through lactation day 21. Effects on the offspring included stunted growth at 5.4 mg cobalt/kg/day and reduced survival at 21.8 mg cobalt/kg/day. In rats treated with 6.2, 12.4, or 24.8 mg cobalt/kg/day on gestation days 6 through 15, maternal effects included reduced food consumption and body weight gain and altered hematologic parameters, although it is unclear at what dose level(s) these effects occurred. There were no effects on fetal survival, although a nonsignificant increase in fetal stunting was observed in rats treated with 12.4 mg cobalt/kg/day. Mice treated with 81.7 mg cobalt/kg/day had reduced maternal weight gain, but no fetal effects.

Several studies reported testicular degeneration and atrophy in rats treated with cobalt chloride in the diet or drinking water at concentrations equivalent to doses of 5.7 to 30.2 mg cobalt/kg/day (EPA 1992). Cobalt is nutritionally essential as a cofactor in cyanocobalamin (vitamin B12) (EPA 1992). Cobalt is universally present in the diet. Average daily adult dietary intakes of cobalt range from 0.16 to 0.58 mg/day (0.002 to 0.008 mg/kg/day, assuming adults weigh 70 kg) (Tipton et al. 1966; Schroeder et al. 1967). In 9- to 12-year-old children, dietary intakes of cobalt range from 0.3 to 1.77 mg/day (Murthy et al. 1971; National Research Council 1989). Assuming an average weight for children in this age range of 28 kg (National Research Council, 1989), the dietary intakes are equivalent to 0.01 to 0.06 mg/kg/day.

EPA (1999a) presented an oral RfD for cobalt of 6.00E-02 mg/kg/day based on the upper range of dietary intake for children (NCEA). Important target organs in orally exposed humans are the heart and erythrocyte. EPA (1999b) has not published an RfC or Inhalation RfD for cobalt.

A.10.2 Carcinogenicity

Data regarding the carcinogenicity of cobalt were not available (EPA 1999b).

A.11 Cyanide

A.11.1 Non-carcinogenic Toxicity

EPA (1999b) published a oral RfD of 2.00E-02 mg/kg/day for cyanide based on a NOAEL in a rat chronic oral feeding study based on effects measured such as weight loss, thyroid effects, and myelin degeneration. EPA (1999b) has not published an RfC or Inhalation RfD for cyanide.

A.11.2 Carcinogenicity

EPA (1999b) classifies cyanide in cancer weight-of-evidence Group D (not classifiable as to carcinogenicity to humans).

A.12 2,4-Dimethylphenol

A.12.1 Non-carcinogenic Toxicity

EPA (1999b) published a oral RfD of 2.00E-02 mg/kg/day for 2,4-dimethylphenol based on a NOAEL in a ninety-day gavage study in Albino mice using 2,4-dimethylphenol. EPA (1999b) has not published an RfC or Inhalation RfD for 2,4-dimethylphenol.

A.1 2.2 Carcinogenicity

2,4-Dimethylphenol has not undergone a complete evaluation and determination under US EPA's IRIS program for evidence of human carcinogenic potential (EPA 1999b).

A.13 Iron

A.13.1 Non-carcinogenic Toxicity

Iron is potentially toxic in all forms and by all routes of exposure. Inorganic iron is a poison by the intraperitoneal route. The inhalation of large amounts of iron dust may result in iron pneumoconiosis or arc welders lung. Chronic exposure to excess levels of iron (>50-100 mg Iron/day) can result in pathological deposition of iron in tissues. The target organs are the pancreas and liver (Sax and Lewis 1989).

Iron compounds are of varying toxicity. Iron oxides are a potential risk in all industrial settings. In general, ferrous compounds are more toxic than ferric compounds. Acute exposure to excessive levels of ferrous compounds can cause liver and kidney damage, altered respiratory rates and convulsions (Sax and Lewis 1989). An oral RfD of 3.00E-01 mg/kg/day has been published for iron by EPA (ECAO). EPA (1999b) has not published an RfC or Inhalation RfD for iron.

A.13.2 Carcinogenicity

Some iron compounds are suspected human carcinogens. Iron dust is an experimental neoplastigen and an increased incidence of lung cancer has been associated with exposure to iron dust. Iron oxide is an experimental tumorigen and a suspected human carcinogen. (Sax and Lewis 1989). EPA (1999b) has not published oral or inhalation SFs for iron.

A.14 Lead

A.14.1 Pharmacokinetics

Studies in humans indicate that an average of 10 percent of ingested lead is absorbed, but estimates as high as 40 percent were obtained in some individuals (Tsuchiya 1986). Nutritional factors have a profound effect on GI absorption efficiency. Children absorb ingested lead more efficiently than adults; absorption efficiencies up to 53 percent were recorded for children three months to eight years of age. Similar results were obtained for laboratory animals; absorption efficiencies of 5 to 10 percent were obtained for adults and 50 percent were obtained for young animals. The deposition rate of inhaled lead averages approximately 30 to 50 percent, depending on particle size. All lead deposited in the lungs is eventually absorbed.

Approximately 95 percent of the lead in the blood is located in the erythrocytes (EPA 1991a). Lead in the plasma exchanges with several body compartments, including the internal organs, bone, and several excretory pathways. In humans, lead concentrations in bone increase with age (Tsuchiya 1986). About 90 percent of the body burden of lead is located in the skeleton. Neonatal blood concentrations are about 85 percent of maternal concentrations. Excretion of absorbed lead is principally through the urine, although GI secretion, biliary excretion, and loss through hair, nails, and sweat are also significant.

A.14.2 Non-carcinogenic Toxicity

The non-carcinogenic toxicity of lead to humans has been well characterized through decades of medical observation and scientific research (EPA 1999b). The principal effects of acute oral exposure are colic with diffuse paroxysmal abdominal pain (probably due to vagal irritation), anemia, and, in severe cases, acute encephalopathy, particularly in children (Tsuchiya 1986). The primary effects of long-term exposure are neurological and hematological. Limited occupational data indicate that long-term exposure to lead may induce kidney damage. The principal target organs of lead toxicity are the erythrocyte and the nervous system. Some of the effects on the blood, particularly changes in levels of certain blood enzymes, and subtle neurologic behavioral changes in children, appear to occur at levels so low as to be considered non-threshold effects.

EPA (1999b) presents no inhalation RfC for lead, but referred to the National Ambient Air Quality Standard (NAAQS) for lead. The NAAQSs are based solely on human health considerations and are designed to protect the most sensitive subgroup of the human population. The NAAQS for lead is 1.5 ug/m3, averaged quarterly (EPA 1999b).

EPA (1991a, 1999b) determined that it is inappropriate to derive an RfD for oral exposure to lead for several reasons. First, the use of an RfD assumes that a threshold for toxicity exists, below which adverse effects are not expected to occur; however, the most sensitive effects of lead exposure, impaired neurologic behavioral development in children and altered blood enzyme levels associated with anemia, may occur at blood lead concentrations so low as to be considered practically non-threshold in nature. Second, RfD values are specific for the route of exposure for which they are derived. Lead, however, is ubiquitous, so that exposure occurs from virtually all media and by all pathways simultaneously, making it practically impossible to quantify the contribution to blood lead from any one route of exposure. Finally, the dose-response relationships common to many toxicants, and upon which derivation of an RfD is based, do not hold true for lead. This is because the fate of lead within the body depends, in part, on the amount and rate of previous exposures, the age of the recipient, and the rate of exposure. There is, however, a reasonably good correlation between blood lead concentration and effect. Therefore, blood lead concentration is the appropriate parameter on which to base the regulation of lead.

EPA IEUBK lead model is an iterated set of equations that estimate blood lead concentration in children aged 0 to 7 years (EPA 1991a; 1991b). The biokinetic part of the model describes the movement of lead between the plasma and several body compartments and estimates the resultant blood lead concentration. The rate of the movement of lead between the plasma and each compartment is a function of the transition or residence time (i.e., the mean time for lead to leave the plasma and enter a given compartment, or the mean residence time for lead in that compartment). Compartments modeled include the erythrocytes, liver, kidneys, all the other soft tissue of the body, cortical bone, and trabecular bone. Excretory pathways and their rates are also modeled. These include the mean time for excretion from the plasma to the urine, from the liver to the bile, and from the other soft tissues to the hair, skin, sweat, etc. The model permits the user to adjust the transition and residence times.

EPA guidance establishes an interim soil cleanup level for lead of 400 parts per million (ppm) to be applied at Superfund sites. This value is considered by EPA to be protective for direct contact with lead-contaminated soils in residential settings. The guidance is to be followed when current or predicted land use is residential.

A.15.3 Carcinogenicity

EPA (1999b) classifies lead in cancer weight-of-evidence Group B2 (probable human carcinogen), based on inadequate evidence of cancer in humans and sufficient animal evidence. The human data consist of several epidemiological occupational studies that yielded confusing results. All of the studies lacked quantitative exposure data and failed to control for smoking and concomitant exposure to other possibly carcinogenic metals. Rat and mouse bioassays showed statistically significant increases in renal tumors following dietary and subcutaneous exposure to several soluble lead salts. Various lead compounds were observed to induce chromosomal alterations in vivo and in vitro, sister chromatid exchange in exposed workers, and cell transformation in Syrian hamster embryo cells; to enhance simian adenovirus induction; and to alter molecular processes that regulate gene expression. EPA (1999b) declined to estimate risk for oral exposure to lead because many factors (e.g., age, general health, nutritional status, existing body burden and duration of exposure) influence the bioavailability of ingested lead, introducing a great deal of uncertainty into any estimate of risk.

A.16 Manganese

A.16.1 Non-carcinogenic Toxicity

Manganese is nutritionally required in humans for normal growth and health (EPA 1999b). The elderly appeared to be more sensitive than children. Oral treatment of laboratory rodents induced biochemical changes in the brain, but rodents did not exhibit the neurological signs exhibited by humans. Occupational exposure to high concentrations in air induced a generally typical spectrum of neurological effects, and increased incidence of pneumonia (ACGIH 1986).

EPA (1999b) published an oral RfD for manganese of 0.024 mg/kg/day based on drinking water and an oral RfD of 0.14 mg/kg/day based on food. EPA (1999b) presented a verified chronic inhalation RfC based on a LOAEL for impairment of neurobehavioral function in occupationally exposed humans. The inhalation RfC is equivalent to 1.43E-05 mg/kg/day, assuming humans inhale 20 m3 of air/day and weigh 70 kg. The CNS and respiratory tract are target organs of inhalation exposure to manganese.

A.16.2 Carcinogenicity

EPA (1999b) classifies manganese in cancer weight-of-evidence Group D (not classifiable as to carcinogenicity to humans).

A.17 2-Methylphenol

A.17.1 Non-carcinogenic Toxicity

EPA (1999b) published an oral RfD of 5.00E-02 mg/kg/day for 2-methylphenol based on a NOAEL in a ninety-day oral toxicity and neurotoxicity study in rats. EPA (1999b) has not published an RfC or Inhalation RfD for 2-methylphenol.

A.17.2 Carcinogenicity

EPA (1999b) classifies 2-methylphenol in cancer weight-of-evidence Group C (possible human carcinogen), based on inadequate human data and limited animal data. The animal data was based on an increased incidence of skin papillomas in mice in an initiation-promotion study. The three cresol isomers produced positive results in genetic toxicity studies both alone and in combination. EPA (1999b) did not establish an oral SF and/or an inhalation unit risk for 2-methylphenol.

A.18 4-Methylphenol

A.18.1 Non-carcinogenic Toxicity

EPA (1997) published a oral RfD of 5.00E-03 mg/kg/day for 4-methylphenol based on CNS, respiratory, and whole body effects in a rabbit gavage study. EPA (1999b) has not published an RfC or Inhalation RfD for 4-methylphenol.

A.18.2 Carcinogenicity

EPA (1999b) classifies 4-methylphenol in cancer weight-of-evidence Group C (possible human carcinogen), based on inadequate human data and limited animal data. The animal data was based on an increased incidence of skin papillomas in mice in an initiation-promotion study. The three cresol isomers produced positive results in genetic toxicity studies both alone and in combination. EPA (1999b) did not establish an oral SF and/or an inhalation unit risk for 4-methylphenol.

A.19 Mercury

Mercury occurs in three forms: elemental, organic, and inorganic. Although the toxicity of all forms is mediated by the mercury cation, the extent of absorption and pattern of distribution within the body, which determines the effects observed, depends on the form to which the organism is exposed (Goyer 1991). Bacterial activity in the environment converts inorganic mercury to methyl mercury (Berlin 1986). It is likely that either inorganic mercury or methyl mercury may be taken up by plants and enter the food chain, and this discussion will focus on inorganic and methyl mercury. Exposure to elemental mercury, which is more likely to occur in an occupational setting, is not discussed herein.

A.19.1 Pharmacokinetics

The GI absorption of inorganic mercury salts is about 2 to 10 percent in humans, and slightly higher in experimental animals (Berlin 1986; Goyer 1991). Inorganic mercury in the blood is roughly equally divided between the plasma and erythrocytes. Distribution is preferentially to the kidney, with somewhat lower concentrations found in the liver, and even lower levels found in the skin, spleen, testes, and brain (Berlin 1986). Inorganic mercury is excreted principally through the feces and urine, with minor pathways including the secretions of exocrine glands and exhalation of elemental mercury vapor.

Methyl mercury is nearly completely (90 to 95 percent) absorbed from the GI tract (Berlin 1986). The concentration of methyl mercury in the erythrocytes is about 10 times that in the plasma. Methyl mercury leaves the blood slowly, showing particular affinity for the brain, particularly in primates. In rats, 1 percent of the body burden of methyl mercury is found in the brain, but in humans, 10 percent of the body burden is found in the brain. Somewhat lower levels are found in the liver and kidney. During pregnancy, methyl mercury accumulates in the fetal brain, often at levels higher than in the maternal brain. Most tissues except the brain transform methyl mercury to inorganic mercury. Excretion of methyl mercury is principally via the bile, with a half-life of 70 days in humans not suffering from toxicity. Following exposure to methyl mercury, some of the mercury in the bile exists as methyl mercury and some as the inorganic form. The inorganic form is largely passed in the feces, but methyl mercury is subject to enterohepatic recirculation. Another important excretory pathway for methyl mercury is lactation.

G.19.2 Non-carcinogenic Toxicity

Target organs for inorganic or methyl mercury include the kidney, nervous system, fetus, and neonate. Acute oral exposure to high doses of inorganic mercury causes severe damage to the GI mucosa because of the corrosive nature of mercury salts, which may lead to bloody diarrhea, shock, circulatory collapse, and death (Berlin 1986a; Goyer 1991). Acute sublethal poisoning induces severe kidney damage. Chronic exposure induces an autoimmune glomerular disease and renal tubular injury. Acute or chronic exposure to methyl mercury leads to neurologic dysfunction (Berlin 1986a; Goyer 1991). The region of the nervous system affected is species-dependent. Methyl mercury poisoning in rats induces peripheral nerve damage and kidney effects. In humans, the sensory cortex appears to be the most sensitive. The brain of the fetus and the neonate may be unusually sensitive to methyl mercury; retarded neurologic development was observed in prenatally exposed children whose mothers showed no clinical signs of poisoning. EPA (1999b) published an oral RfD of 1.00E-04 mg/kg/day for exposure to methyl mercury based on neurological effects in environmentally exposed humans. An intake of 3 ug/kg/day was the LOAEL corresponding to a blood level of 200 ng/mL, which was associated with CNS effects. An uncertainty factor of 10 was used to estimate an NOAEL from an LOAEL. An inhalation RfC of 0.0003 mg/kg/day (uncertainty factor of 30) has been established for inorganic mercury based on neurotoxic effects in humans. This translates into a chronic RfD of 8.60E-05 mg/kg/day (EPA 1999b).

G.19.3 Carcinogenicity

EPA (1999b) classifies inorganic mercury in cancer weight-of-evidence Group D (not classifiable as to carcinogenicity to humans), based on no data regarding cancer in humans, and inadequate animal and supporting data. EPA (1999b) has not yet evaluated the carcinogenicity of organic mercury.

A.20 Nickel

A.20.1 Non-carcinogenic Toxicity

In a subchronic gavage study with nickel chloride in water, clinical signs of toxicity in rats included lethargy, ataxia, irregular breathing, reduced body temperature, salivation, and discolored extremities (EPA 1996). Inhalation exposure was associated with asthma and pulmonary fibrosis in welders using nickel alloys (ACGIH 1986). Lung effects were observed in laboratory animals exposed by inhalation. EPA (1999b) presented a verified RfD of 2.00E-02 for chronic oral exposure to nickel, based on an NOAEL for decreased organ and body weights in a two-year dietary study with nickel sulfate in rats and an uncertainty factor of 300. The nickel RfD is based on decreased organ wieght. The lung is clearly the target organ for inhalation exposure even though EPA (1999b) has not published an RfC or Inhalation RfD for nickel.

A.20.2 Carcinogenicity

Occupational exposure to nickel was associated with increased risk of nasal, laryngeal and lung cancer (ATSDR 1995a). Inhalation exposure of rats to nickel subsulfide increased the incidence of lung tumors. EPA (1999b) presents a cancer weight-of-evidence Group A classification (human carcinogen) for nickel refinery dust. No oral SF or inhalation unit risk was established for elemental nickel, therefore, carcinogenic exposures for nickel are not estimated at this site.

A.21 Phenol

A.21.1 Noncancer Toxicity

EPA (1999b) published a oral RfD of 6.00E-01 mg/kg/day based on a NOAEL of reduced fetal body weights in a teratologic evaluation of phenol in CD rats and mice. EPA (1999b) has not published an RfC or Inhalation RfD for phenol.

A.21.2 Carcinogenicity

Phenol was classified in cancer weight-of-evidence Group D (not classifiable as to carcinogenicity to humans) (EPA 1999b).

A.22 Polyaromatic Hydrocarbons (Carcinogenic)

A.22.1 Pharmacokinetics

Although quantitative absorption data for the PAHs were not located, benzo(a)pyrene was readily absorbed across the GI (Rees et al. 1971) and respiratory epithelia (Kotin et al. 1969; Vainich et al. 1976). The high lipophilicity of other compounds in this class suggests that other PAHs also would be readily absorbed across GI and respiratory epithelia.

Benzo(a)pyrene was distributed widely in the tissues of treated rats and mice, but primarily to tissues high in fat, such as adipose tissue and mammary gland (Kotin et al. 1969; Schlede et al. 1970a). Patterns of tissue distribution of other PAHs would be expected to be similar because of the high lipophilicity of the members of this class.

Studies of the metabolism of benzo(a)pyrene provide information relevant to other PAHs because of the structural similarities of all members of the class. Metabolism involves microsomal mixed function oxidase hydroxylation of one or more of the phenyl rings with the formation of phenols and dihydrodiols, probably via formation of arene oxide intermediates (EPA 1979a). The dihydrodiols may be further oxidized to diol epoxides, which, for certain members of the class, are known to be the ultimate carcinogens (LaVoie et al. 1982). Conjugation with glutathione or glucuronic acid, and reduction to tetrahydrotetrols are important detoxification pathways. Metabolism of naphthalene resulted in the formation of 1,2-naphthoquinone, which induced cataract formation and retinal damage in rats and rabbits.

Excretion of benzo(a)pyrene or dibenz(a,h)anthracene residues was reported to be rapid, although quantitative data were not located (EPA 1979b). Excretion occurred mainly via the feces, probably largely due to biliary secretion (Schlede et al. 1970a, 1970b). EPA (1980) concluded that accumulation in the body tissues of PAHs from chronic low level exposure would be unlikely.

A.22.2 Non-carcinogenic Toxicity

Oral noncancer toxicity data are available for dibenzofuran, fluoranthene, fluorene, 2-methylnaphthalene, naphthalene, and pyrene. EPA (1997, 1999a, 1999b) has not established oral RfDs or inhalation RfCs for the carcinogenic PAHs including benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, carbazole, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

EPA (1999a) presented a oral RfD of 4.00E-03 mg/kg/day for dibenzofuran (NCEA). The target organ dibenzofuran exposure is the kidney. EPA (1999b) has not published an RfC or Inhalation RfD for dibenzofuran.

Fluoranthene appears to be toxic to the liver, kidney, and blood. In a comprehensive 13-week gavage study in mice, 125 mg/kg/day was an NOAEL and 250 mg/kg/day was an LOAEL (EPA 1988). The verified chronic oral RfD for fluoranthene is 4.00E-02 mg/kg/day, based on the NOAEL in a comprehensive 13-week gavage study of 125 mg/kg/day in mice and an uncertainty factor of 3000 (EPA 1999b). The uncertainty factor of 3000 includes factors of 10 each for inter- and intraspecies variation, and a factor of 30 to expand from subchronic to chronic exposure and to reflect an incomplete database. The liver, kidney, and blood appear to be the target organs for the toxicity of fluoranthene. EPA (1999b) has not published an RfC or Inhalation RfD for fluoranthene.

The critical effects of oral exposure to fluorene appear to be hemolytic anemia and CNS effects. In mice treated by gavage for 13 weeks, 125 mg/kg/day was an NOAEL and 250 mg/kg/day was an LOAEL (EPA 1989b). A verified chronic oral RfD for fluorene of 4.00E-02 mg/kg/day was based on the NOAEL of 125 mg/kg/day for hemolytic anemia in mice (EPA 1999b). An uncertainty factor of 3000 was used with factors of 10 each for inter- and intraspecies variation and to expand from subchronic to chronic exposure, and a factor of 3 to reflect gaps in the database. The target organs of fluorene toxicity are the erythrocyte and the CNS. EPA (1999b) has not published an RfC or Inhalation RfD for fluorene.

Newborn infants, children, and adults exposed to naphthalene by ingestion, inhalation, or possibly by skin contact developed hemolytic anemia with jaundice and, occasionally, renal disease (EPA 1980). EPA (1999b) established a oral RfD of 2.00E-02 mg/kg/day for naphthalene based on a NOAEL in an unpublished subchronic toxicity study using Fischer 344 rats. The effects of the study included mean terminal body weights in male Fischer 344 rats. EPA (1999b) has published an Inhalation RfD of 9.00E-04 for naphthalene.

EPA (1999a) presented a oral RfD of 2.00E-02 mg/kg/day for 2-methylnaphthalene (NCEA). This is based on the likelihood that 2-methylnaphthalene is no more toxic than naphthalene. The target organ for 2-methylnaphthalene exposure is weight loss. EPA (1999b) has not published an RfC or Inhalation RfD for 2-methylnaphthalene.

Mild kidney lesions appear to be the critical effects of pyrene. In mice treated by gavage for 13 weeks, 75 mg/kg/day was an NOAEL and 125 mg/kg/day was an LOAEL (EPA 1989c). Even in mice treated with 250 mg/kg/day the lesions were considered minimal to mild. EPA (1999b) verified a chronic oral RfD for pyrene of 3.00E-02 mg/kg/day based on the NOAEL in mice and an uncertainty factor of 3000 (10 each for inter- and intraspecies variation and to expand from subchronic to chronic exposure, and a factor of 3 to reflect gaps in the database). The kidney is the target organ for the toxicity of pyrene. EPA (1999b) has not published an RfC or Inhalation RfD for pyrene.

A.22.3 Carcinogenicity

The PAHs are ubiquitous, being released to the environment from anthropogenic as well as from natural sources (ATSDR 1987). Benzo(a)pyrene is the most extensively studied member of the class, inducing tumors in multiple tissues of virtually all laboratory species tested by all routes of exposure. Although epidemiology studies suggested that complex mixtures that contain PAHs (coal tar, soot's, coke oven emissions, cigarette smoke) are carcinogenic to humans, the carcinogenicity cannot be attributed to PAHs alone because of the presence of other potentially carcinogenic substances in these mixtures (ATSDR 1987). In addition, recent investigations showed that the PAH fraction of roofing tar, cigarette smoke, and coke oven emissions accounted for only 0.1 to 8 percent of the total mutagenic activity of the unfractionated complex mixture in Salmonella (Lewtas 1988). Aromatic amines, nitrogen heterocyclic compounds, highly oxygenated quinones, diones, and nitrooxygenated compounds, none of which would be expected to arise from in vivo metabolism of PAHs, probably accounted for the majority of the mutagenicity of coke oven emissions and cigarette smoke. Furthermore, coal tar, which contains a mixture of many PAHs, has a long history of use in the clinical treatment of a variety of skin disorders in humans (ATSDR 1987).

Because of the lack of human cancer data, assignment of individual PAHs to EPA cancer weight-of-evidence groups was based largely on the results of animal studies with large doses of purified compound. Frequently, unnatural routes of exposure, including implants of the test chemical in beeswax and trioctanoin in the lungs of female Osborne-Mendel rats, intratracheal instillation, and subcutaneous or intraperitoneal injection, were used. Benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, carbazole, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)pyrene were classified in Group B2 (probable human carcinogens) (EPA 1997, 1999b).

EPA (1999b) verified a SF for oral exposure to benzo(a)pyrene of 7.3 per mg/kg/day, based on several dietary studies in mice and rats. Neither verified nor provisional quantitative risk estimates were available for the other PAHs in Group B2. EPA (1980) promulgated an ambient water quality criterion for "total carcinogenic PAHs," based on an oral SF derived from a study with benzo(a)pyrene, as being sufficiently protective for the class. Largely because of this precedent, the quantitative risk estimates for the other carcinogenic PAHs were based on benzo(a)pyrene when quantitative estimates were needed.

Recent reevaluations of the carcinogenicity and mutagenicity of the Group B2 PAHs suggest that there are large differences between individual PAHs in cancer potency (Krewski et al., 1989). Based on the available cancer and mutagenicity data, and assuming that there is a constant relative potency between different carcinogens across different bioassay systems and that the PAHs under consideration have similar dose-response curves, Thorslund and Charnley (1988) derived relative potency values for several PAHs. A more recent Relative Potency Factor (RPF) scheme for the Group B2 PAHs was based only on the induction of lung epidermoid carcinomas in female Osborne-Mendel rats in the lung-implantation experiments (Clement International 1990).

Carcinogenic PAHs are related by chemical structure. All other carcinogenic PAHs except carbazole have SFs based on their potency relative to benzo(a)pyrene. These factors are published by EPA (Clement International 1990). The relative potency factors are as follows for the carcinogenic PAHs:

Constituent	Relative Potency Factor
Benzo(a)pyrene	1.0
Benz(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.01
Chrysene	0.001
Dibenz(a,h)anthracene	1.0
Indeno(1,2,3-cd)pyrene)	0.1

Carbazole had an EPA (1999b) listed oral SF of 2E-02 per mg/kg/day. The SF was based on a observations of liver tumors in mice.

EPA (1999a) presented an inhalation SF of 3.1E-01 per mg/kg/day (NCEA) for benzo(a)pyrene. The other carcinogenic PAHs do not have established inhalation SFs and are not subjected to toxicity equivalency factors regarding inhalation criteria.

A.23 Selenium

A.23.1 Noncancer Toxicity

Selenium is a nutritionally essential trace element that is an integral part of the enzyme glutathione peroxidase and other proteins (Högberg and Alexander 1986). The National Research Council (1989) recommended dietary allowances (RDAs) for humans range from 10 to 75 mg/day. Chronic ingestion of 5 mg/day (0.071 mg/kg/day, assuming humans weigh 70 kg) induced selenosis in humans, characterized by abnormal hair and nail formation (Högberg and Alexander 1986). Effects in domestic grazing animals exposed to high levels of selenium included emaciation, lameness, and loss of hair and hooves. Occupational exposure to selenium fume or various selenium compounds was associated with intense ocular and respiratory tract irritation, chemical pneumonia, skin rashes, garlic odor to the breath, metallic taste in the mouth, and various socio-psychological effects (ACGIH 1986). EPA (1999b) presented a verified RfD of 5.00E-03 mg/kg/day for chronic oral exposure to selenourea, based on effects in humans exposed to selenium in high selenium areas. An uncertainty factor of 3 was used. The principal target organs for oral exposure to selenium are the skin, including the nails and hair, and, in animals, the hooves and joints. Targets for inhalation or dermal exposure include the skin and mucous membranes of the eyes and respiratory tract, and possibly the CNS. EPA (1999b) has not published an RfC or Inhalation RfD for selenium.

A.23.2 Carcinogenicity

An impressive body of data indicates that selenium exerts an anticarcinogenic effect (Högberg and Alexander 1986). In laboratory animals, selenium supplementation decreased the incidence of chemical-induced cancers. In humans, the incidence of lymphomas and cancers of the breast, digestive tract, and lung were lower in geographic areas with high soil selenium levels. Occupational data suggest that selenium may protect against lung cancer. Several animal tests with various deficiencies in design and conduct equivocally associated exposure to selenium with cancer induction. In a well controlled oral experiment, selenium sulfide was associated with an increase in the incidence of liver tumors in rats, and with liver and lung tumors in mice. On the basis of this study, EPA (1999b) classified selenium sulfide a cancer weight-of-evidence Group B2 compound (probable human carcinogen), but declined to derive quantitative risk estimates. Selenium and other selenium compounds were classified in cancer weight-of-evidence Group D (not classifiable as to carcinogenicity to humans) (EPA 1999b).

A.24 Thallium

A.24.1 Non-carcinogenic Toxicity

Thallium is highly toxic; acute ingestion by humans or laboratory animals induced gastroenteritis, neurological dysfunction, and renal and liver damage (Kazantis, 1986). Chronic ingestion of more moderate doses characteristically caused alopecia. Thallium was used medicinally to induce alopecia in cases of ringworm of the scalp, sometimes with disastrous results. Ininudstrial (inhlation, oral, dermal) exposure, neurologic signs preceded alopecia, suggesting that the nervous system is more sensitive than the hair follicle. EPA (1999b) presented verified chronic oral RfD values for several thallium compounds (thallium acetate, thallium carbonate, thallium chloride, thallium nitrate, thallium sulfate, and thallic oxide) based on increased incidence of alopecia and increased serum levels of liver enzymes indicative of hepatocellular damage in rats treated with thallium sulfate for 90 days. EPA (1999a) presented a chronic oral RfD for thallium of 7.00E-05 mg/kg/day (NCEA). This is based on adjusting the IRIS RfDs for thallium compounds by the weight of thallium. EPA (1999b) has not published an RfC or Inhalation RfD for thallium.

A.24.2 Carcinogenicity

Several thallium compounds (thallium oxide, thallium acetate, thallium carbonate, thallium chloride, thallium nitrate, thallium sulfate) were classified as cancer weight-of-evidence Group D substances (not classifiable as to carcinogenicity to humans) (EPA 1994, 1999b). No weight-of-evidence classification was located for thallium alone.

A.25 Vanadium

A.25.1 Non-carcinogenic Toxicity

In a chronic study, an unspecified number of rats were exposed to dietary levels of 10 or 100 ppm vanadium (about 17.9 or 179 ppm vanadium pentoxide) for 2.5 years. The results of this unpublished study were summarized by Stokinger et al. (1981). The criteria used to evaluate vanadium toxicity were growth rate, survival, and hair cystine content. The only significant change reported was a decrease in the amount of cystine in the hair of animals ingesting vanadium. EPA (1997) presented an oral RfD of 7.00E-03 mg/kg/day based on a NOAEL in a lifetime rat drinking water study. EPA (1999b) has not published an RfC or Inhalation RfD for vanadium.

A.25.2 Carcinogenicity

EPA (1999b) classifies vanadium in cancer weight-of-evidence Group D (not classifiable as to carcinogenicity to humans).

A.26 Zinc

A.26.1 Pharmacokinetics

Zinc is a nutritionally required trace element. Estimates of the efficiency of GI absorption of zinc in animals range from <10 to 90 percent (Elinder 1986c). Estimates in normal humans range from approximately 20 to 77 percent (Elinder 1986c; Goyer 1991). The net absorption of zinc appears to be homeostatically controlled, but it is unclear whether GI absorption, intestinal secretion, or both are regulated. Distribution of absorbed zinc is primarily to the liver (Goyer 1991), with subsequent redistribution to bone, muscle, and kidney (Elinder 1986c). Highest tissue concentrations are found in the prostate. Excretion appears to be principally through the feces, in part from biliary secretion, but the relative importance of fecal and urinary excretion is species-dependent. The half-life of zinc absorbed from the GI tracts of humans in normal zinc homeostasis is approximately 162 to 500 days.

A.26.2 Non-carcinogenic Toxicity

Humans exposed to high concentrations of aerosols of zinc compounds may experience severe pulmonary damage and death (Elinder 1986c). The usual occupational exposure is to freshly formed fumes of zinc, which can induce a reversible syndrome known as metal fume fever. Orally, zinc exhibits a low order of acute toxicity. Animals dosed with 100 times dietary requirement showed no evidence of toxicity (Goyer 1991). In humans, acute poisoning from foods or beverages prepared in galvanized containers is characterized by GI upset (Elinder 1986c). Chronic oral toxicity in animals is associated with poor growth, GI inflammation, arthritis, lameness, and a microcytic, hypochromic anemia (Elinder 1986c), possibly secondary to copper deficiency (Underwood 1977). EPA (1999b) presented a verified RfD of 3.00E-01 mg/kg/day for chronic oral exposure to zinc, based on anemia in humans. EPA (1999b) has not published an RfC or Inhalation RfD for zinc.

A.26.3 Carcinogenicity

EPA (1999b) classifies zinc in cancer weight-of-evidence Group D (not classifiable as to carcinogenicity to humans) based on inadequate evidence for carcinogenicity in humans and animals. The human data consist largely of occupational exposure studies not designed to detect a carcinogenic response, and of reports that prostatic zinc concentrations were lower in cancerous than in noncancerous tissue. The animal data consist of several dietary, drinking water, and zinc injection studies, none of which provided convincing data for a carcinogenic response.

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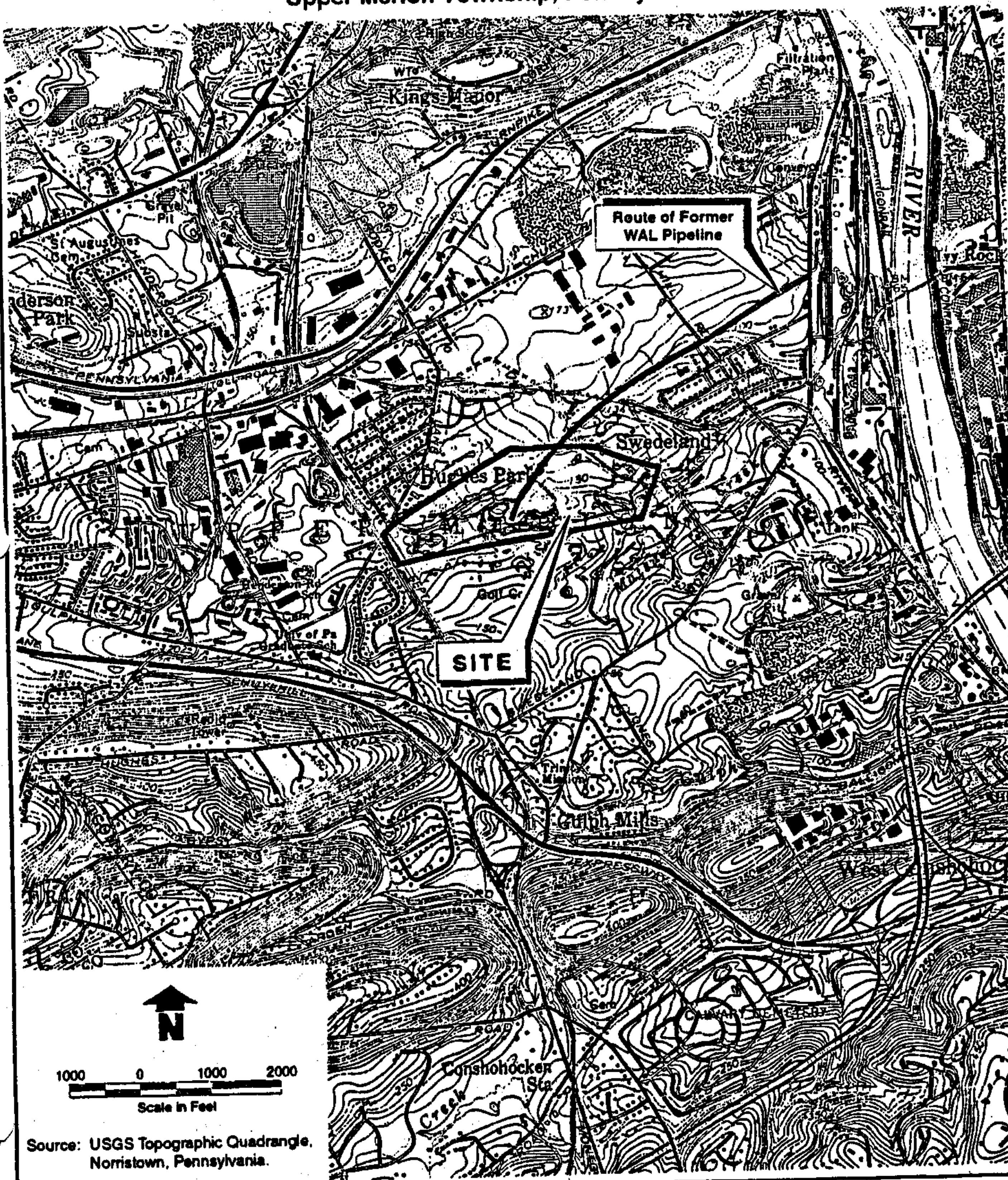
FIGURES

Figure 1
Site Location Map
Crater Resources Site
Upper Merion Township, Pennsylvania



Source: USGS Topographic Quadrangle, Norristown, Pennsylvania.

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Figure 2
Site Topographic Map
Crater Resources Site
Upper Merion Twp., Pennsylvania

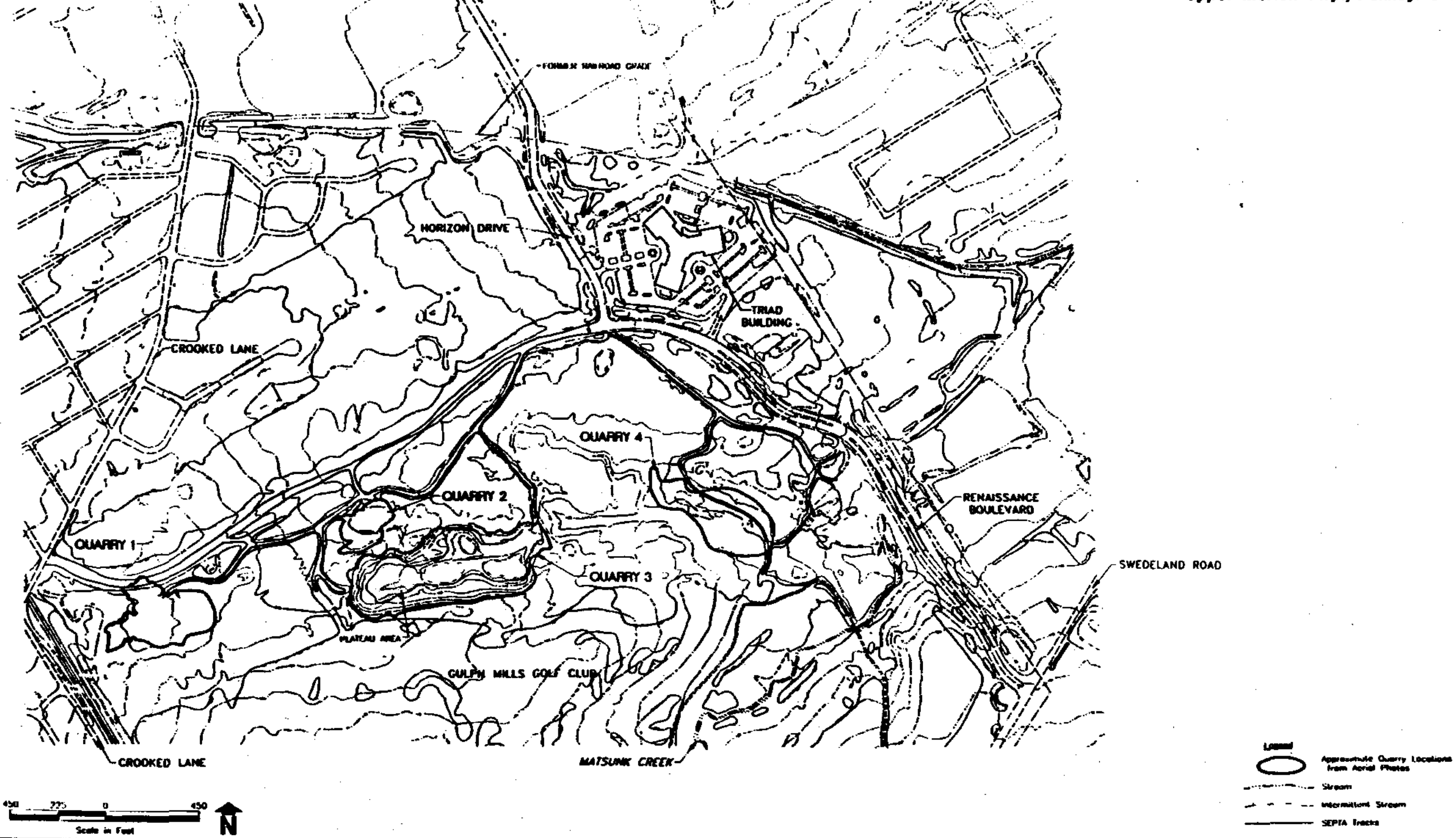


Figure 3
Regional Geology Map
Crater Resources Site
Upper Merion Township, Pennsylvania

LEGEND

Tpb
Pensauken and Bridgeton Fms., undif.

Tbm
Bryn Mawr Fm.

Kp
Patapsco (?) Fm.

Ꞁd
Diabase

Ꞁs
Stockton Fm.

O€c
Constoga Fm.

€e
Elbrook Fm.

€l
Ledger Fm

€ah
Antietam and Harpers Fms., undiv

€ch
Chickies Fm.

Xgr
Granitic gneiss and granite

Xs
Serpentinite

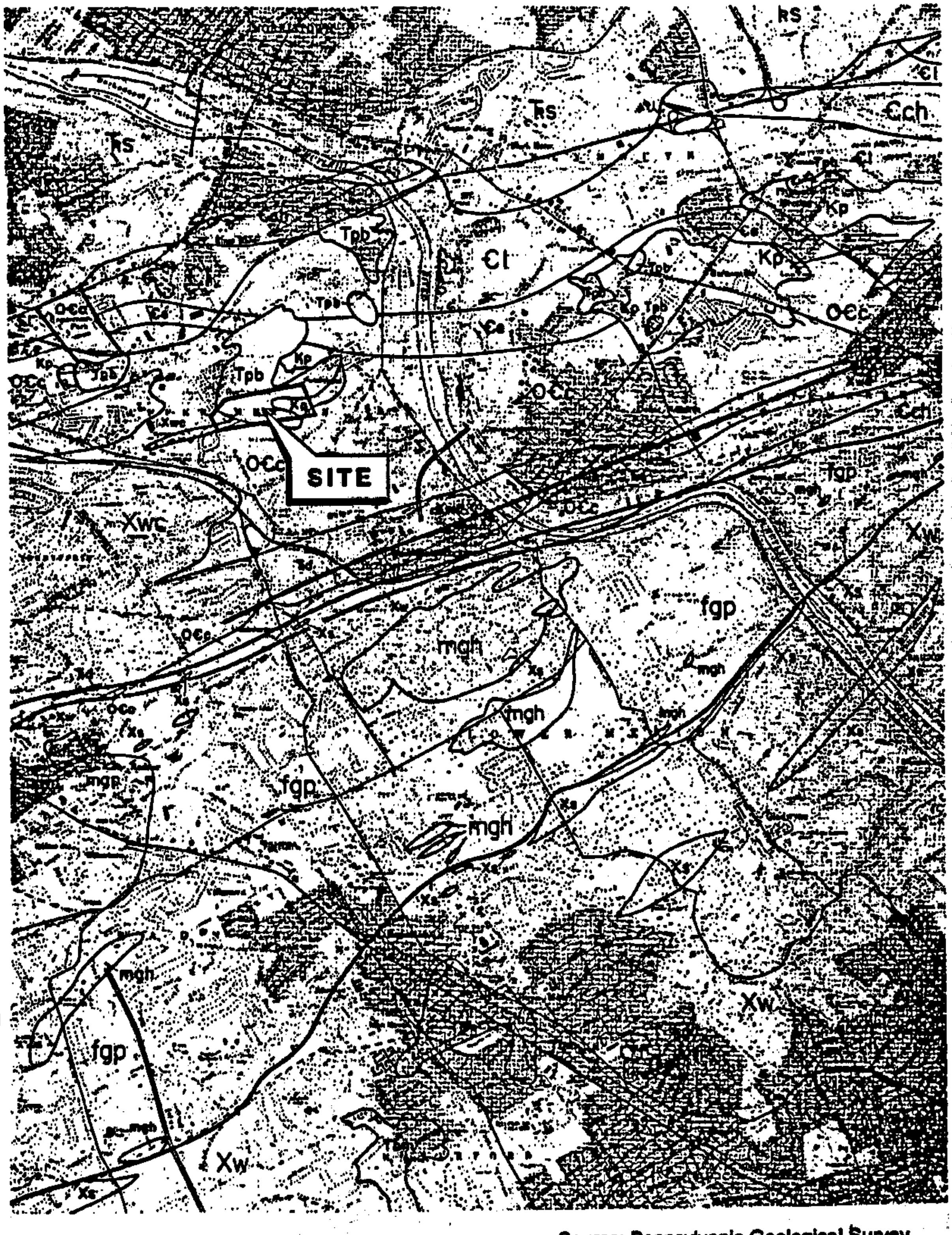
Xwc
Wissahickon Fm., albite - chlorite schist

Xw
Wissahickon Fm., oligoclase - mica schist

fgp
Felsic gneiss pyroxene - bearing

mgh
Mafic gneiss, hornblende - bearing

mgp
Mafic gneiss, pyroxene - bearing



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Source: Pennsylvania Geological Survey, Map 61, Norristown Quadrangle

Figure 4
Quarry 1 Soil Boring Locations
Crater Resources Site
Upper Merion Twp., Pennsylvania

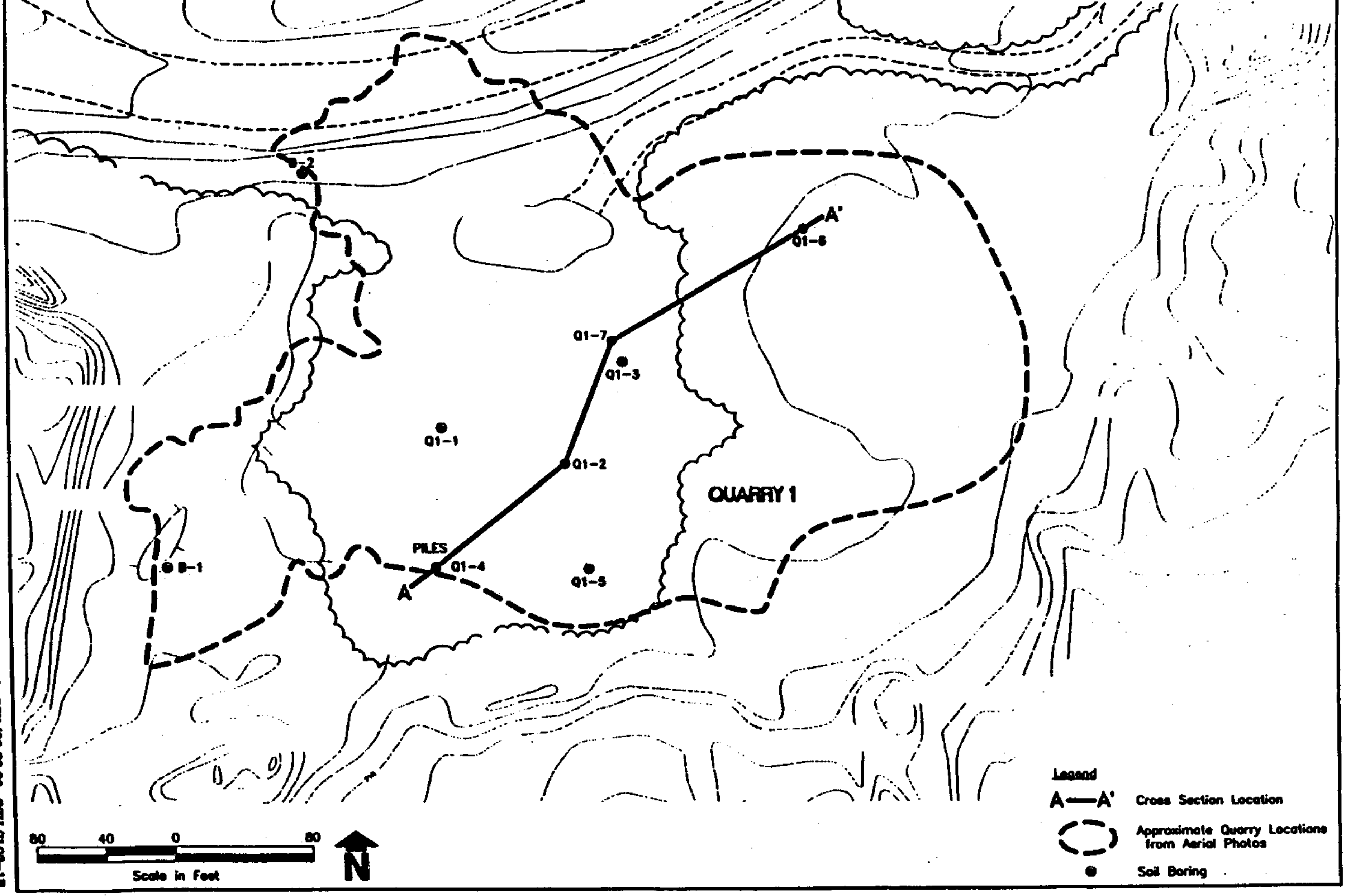
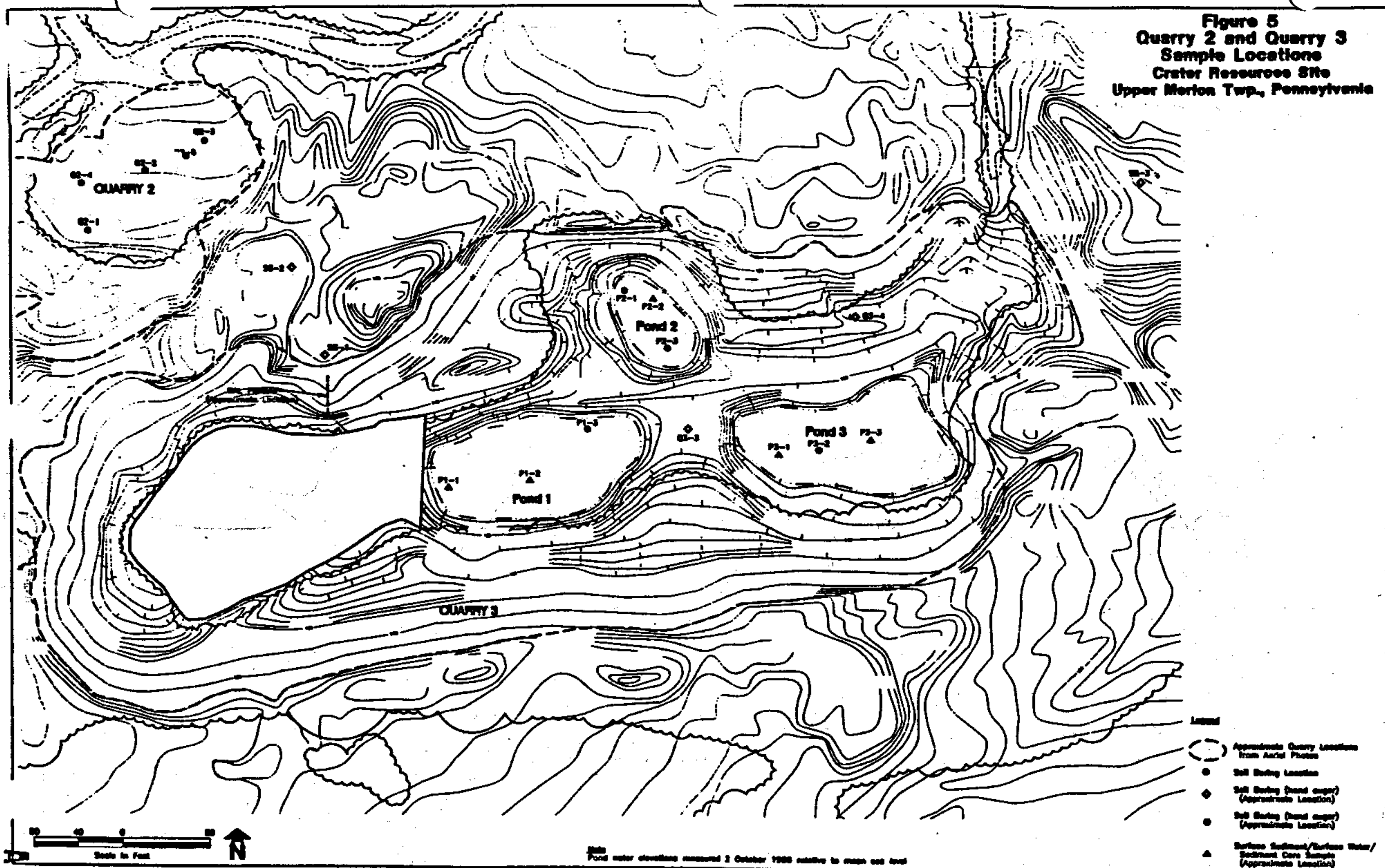
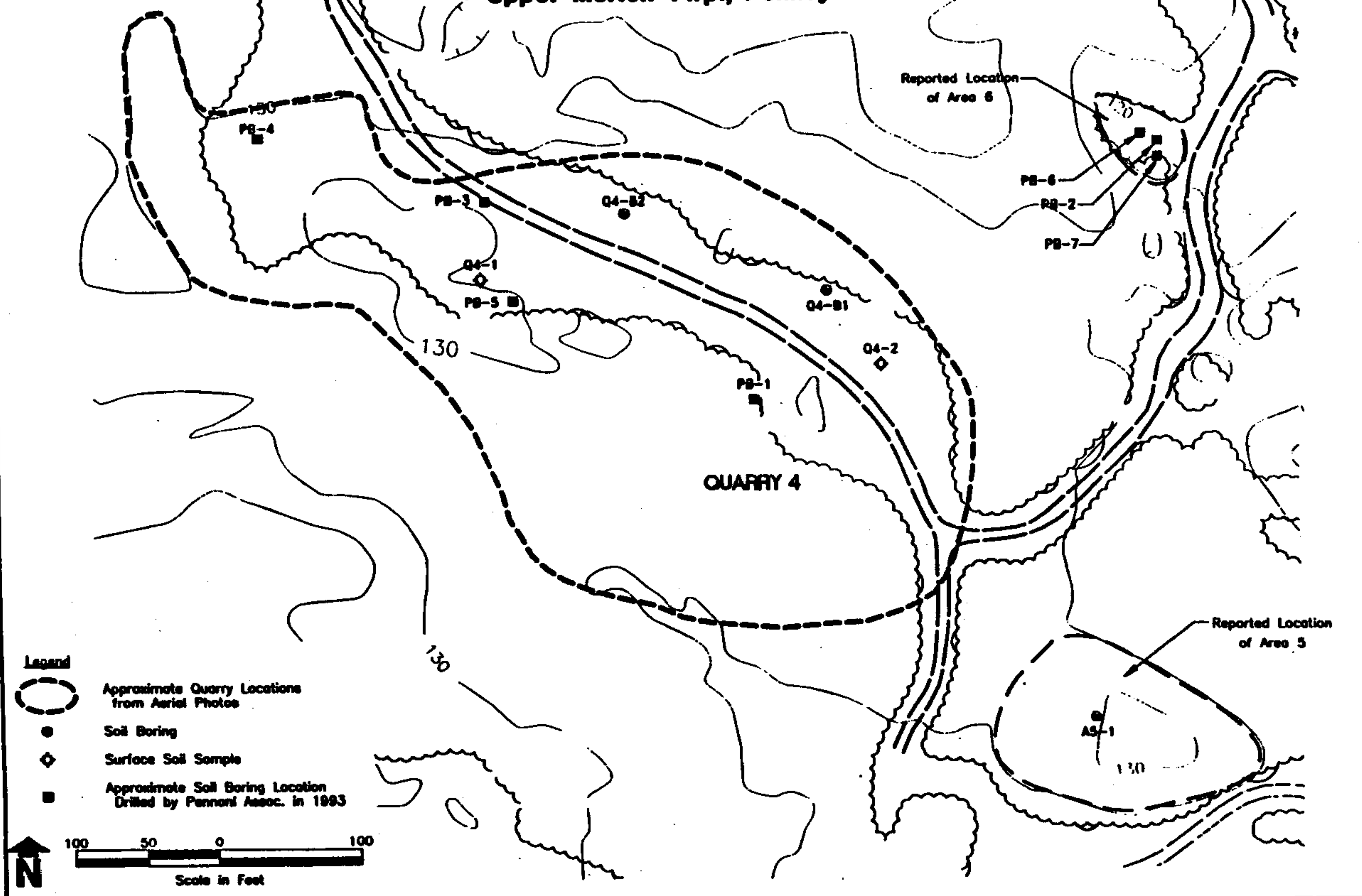


Figure 5
Quarry 2 and Quarry 3
Sample Locations
Crater Resources Site
Upper Merion Twp., Pennsylvania



Note
Pond water elevations measured 2 October 1990 relative to mean sea level

Figure 6
Quarry 4, Area 5 and Area 6 Soil Sample Locations
Crater Resources Site
Upper Merion Twp., Pennsylvania



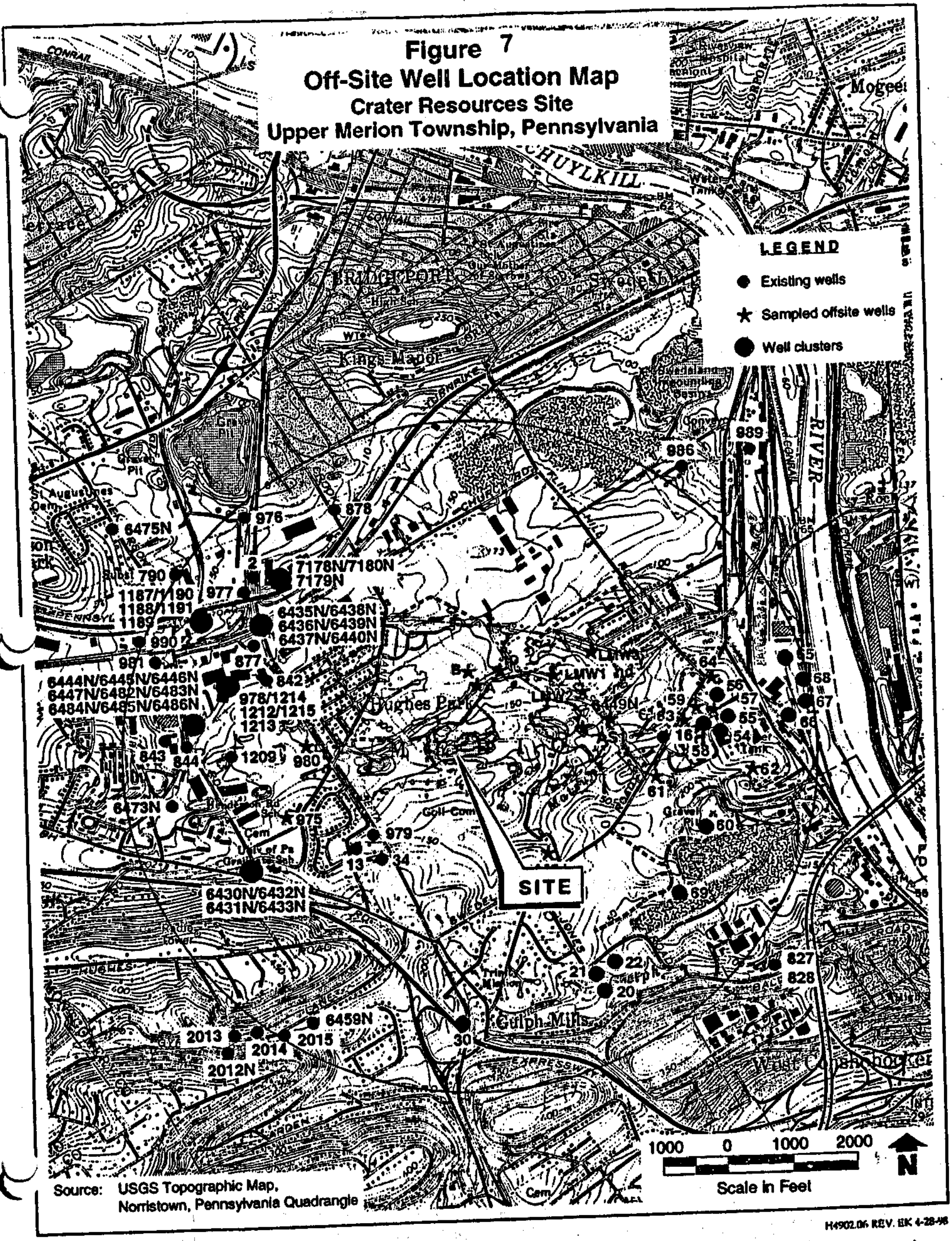


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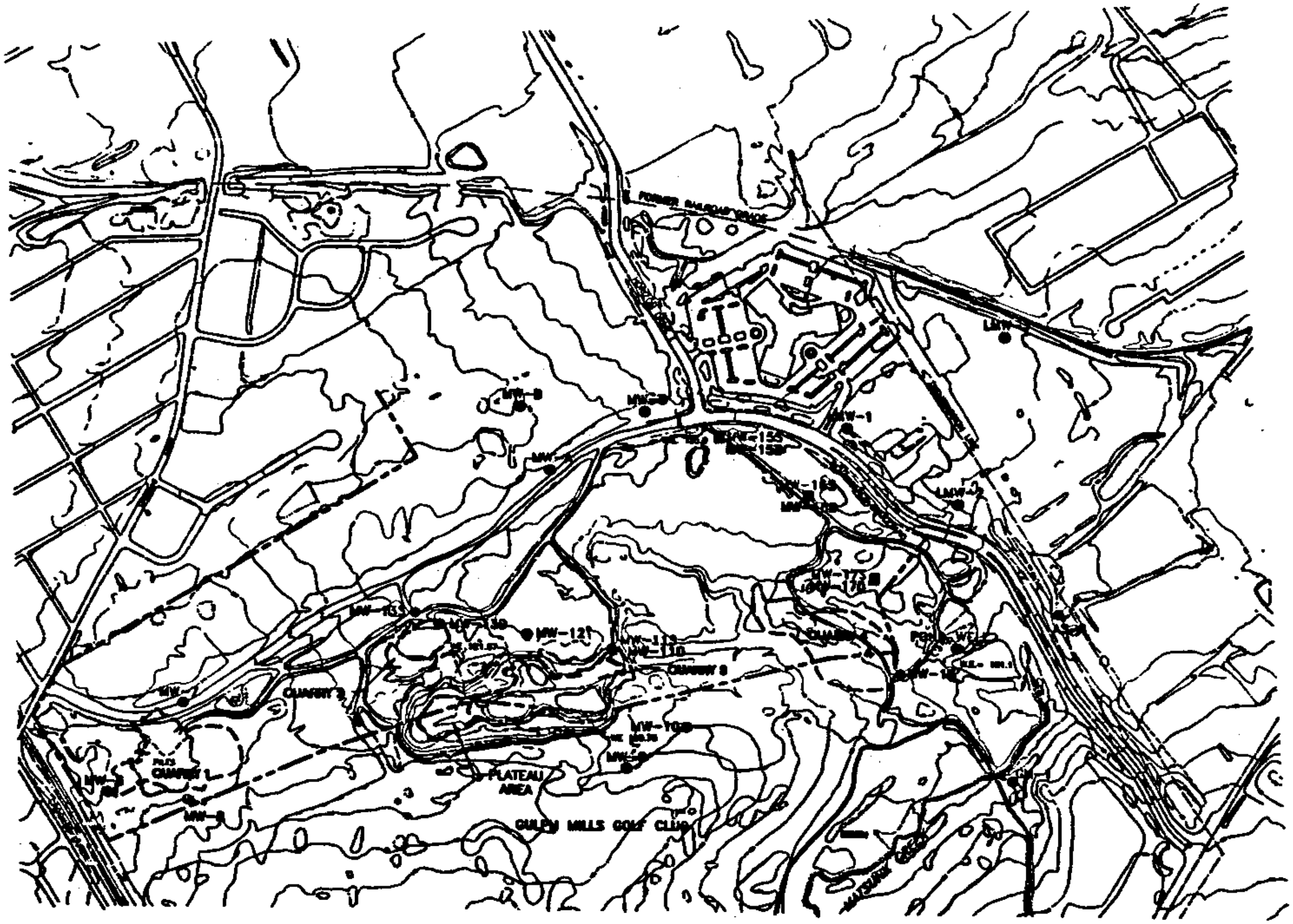
Figure 8
Well Location Map
Crater Resources Site
Upper Merion Twp., Pennsylvania



Legend
Property Boundary
Approximate Quarry Locations from 1959 Aerial Photo
Stream
Intermittent Stream
Off-Site Well
Monitoring Well
Monitoring Well Nest

450 225 0 450
Scale in Feet
N

TABLES

TABLE 1
SELECTION OF EXPOSURE PATHWAYS - QUARRY 1
CRATER RESOURCES

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Populations	Receptor Age	Exposure Routes	On Site/ Off Site	Type of Analysis	Rationale
Current	Surface Soil	Surface Soil	Contact with Quarry 1 Surface Soil; Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Quarry 1 Surface Soil; Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 1 Surface Soil; Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 1 Surface Soil; Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Inhalation	On Site	None	No significant VOCs were detected in Quarry 1 surface soil.
Future	Surface Soil	Surface Soil	Contact with Quarry 1 Surface Soil; Residential Child	Resident	Child	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Quarry 1 Surface Soil; Residential Child	Resident	Child	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 1 Surface Soil; Residential Child	Resident	Child	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 1 Surface Soil; Residential Child	Resident	Child	Inhalation	On Site	None	No significant VOCs were detected in Quarry 1 surface soil.
		Surface Soil	Contact with Quarry 1 Surface Soil; Residential Adult	Resident	Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Quarry 1 Surface Soil; Residential Adult	Resident	Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 1 Surface Soil; Residential Adult	Resident	Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 1 Surface Soil; Residential Adult	Resident	Adult	Inhalation	On Site	None	No significant VOCs were detected in Quarry 1 surface soil.
		Surface Soil	Contact with Quarry 1 Surface Soil; Lifetime Resident	Resident	Child/Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Quarry 1 Surface Soil; Lifetime Resident	Resident	Child/Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 1 Surface Soil; Lifetime Resident	Resident	Child/Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 1 Surface Soil; Lifetime Resident	Resident	Child/Adult	Inhalation	On Site	None	No significant VOCs were detected in Quarry 1 surface soil.
		Surface Soil	Contact with Quarry 1 Surface Soil; Industrial Worker	Industrial Worker	Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Quarry 1 Surface Soil; Industrial Worker	Industrial Worker	Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 1 Surface Soil; Industrial Worker	Industrial Worker	Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 1 Surface Soil; Industrial Worker	Industrial Worker	Adult	Inhalation	On Site	None	No significant VOCs were detected in Quarry 1 surface soil.
	Soil	Soil	Contact with Quarry 1 Soil (Surface and Subsurface); Construction Worker	Construction Worker	Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Soil	Contact with Quarry 1 Soil (Surface and Subsurface); Construction Worker	Construction Worker	Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 1 Soil (Surface and Subsurface); Construction Worker	Construction Worker	Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 1 Soil (Surface and Subsurface); Construction Worker	Construction Worker	Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.

TABLE 1
SELECTION OF EXPO PATHWAYS - QUARRY 2
CRATE SOURCES

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Populations	Receptor Age	Exposure Routes	On Site/ Off Site	Type of Analysis	Rationale
Current	Surface Soil	Surface Soil	Contact with Quarry 2 Surface Soil; Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Quarry 2 Surface Soil; Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 2 Surface Soil; Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 2 Surface Soil; Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Inhalation	On Site	None	No significant VOCs were detected in Quarry 2 surface soil.
Future	Surface Soil	Surface Soil	Contact with Quarry 2 Surface Soil; Residential Child	Resident	Child	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Quarry 2 Surface Soil; Residential Child	Resident	Child	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 2 Surface Soil; Residential Child	Resident	Child	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 2 Surface Soil; Residential Child	Resident	Child	Inhalation	On Site	None	No significant VOCs were detected in Quarry 2 surface soil.
		Surface Soil	Contact with Quarry 2 Surface Soil; Residential Adult	Resident	Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Quarry 2 Surface Soil; Residential Adult	Resident	Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 2 Surface Soil; Residential Adult	Resident	Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 2 Surface Soil; Residential Adult	Resident	Adult	Inhalation	On Site	None	No significant VOCs were detected in Quarry 2 surface soil.
		Surface Soil	Contact with Quarry 2 Surface Soil; Lifetime Resident	Resident	Child/Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Quarry 2 Surface Soil; Lifetime Resident	Resident	Child/Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 2 Surface Soil; Lifetime Resident	Resident	Child/Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 2 Surface Soil; Lifetime Resident	Resident	Child/Adult	Inhalation	On Site	None	No significant VOCs were detected in Quarry 2 surface soil.
		Surface Soil	Contact with Quarry 2 Surface Soil; Industrial Worker	Industrial Worker	Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Quarry 2 Surface Soil; Industrial Worker	Industrial Worker	Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 2 Surface Soil; Industrial Worker	Industrial Worker	Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 2 Surface Soil; Industrial Worker	Industrial Worker	Adult	Inhalation	On Site	None	No significant VOCs were detected in Quarry 2 surface soil.
	Soil	Soil	Contact with Quarry 2 Soil (Surface and Subsurface); Construction Worker	Construction Worker	Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Soil	Contact with Quarry 2 Soil (Surface and Subsurface); Construction Worker	Construction Worker	Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 2 Soil (Surface and Subsurface); Construction Worker	Construction Worker	Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 2 Soil (Surface and Subsurface); Construction Worker	Construction Worker	Adult	Inhalation	On Site	None	No significant VOCs were detected in Quarry 2 soil.

TABLE 1
SELECTION OF EXPOSURE PATHWAYS - QUARRY 3
CRATER RESOURCES

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Populations	Receptor Age	Exposure Routes	On Site/ Off Site	Type of Analysis	Rationale
Current	Surface Soil	Surface Soil	Contact with Quarry 3 Surface Soil; Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Quarry 3 Surface Soil; Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 3 Surface Soil; Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 3 Surface Soil; Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Inhalation	On Site	None	No significant VOCs were detected in Quarry 3 surface soil.
	Sediment	Sediment	Contact with Quarry 3 Sediment; Adolescent Trespasser	Trespasser/Visitor	Adolescent (Teens)	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Sediment	Contact with Quarry 3 Sediment; Adolescent Trespasser	Trespasser/Visitor	Adolescent (Teens)	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure
		Particulates	Inhalation of Particulates in Quarry 3 Sediment; Adolescent Trespasser	Trespasser/Visitor	Adolescent (Teens)	Inhalation	On Site	None	Quarry 3 sediment is expected to be wet, resulting in no exposure
		Air	Inhalation of Volatiles in Quarry 3 Sediment; Adolescent Trespasser	Trespasser/Visitor	Adolescent (Teens)	Inhalation	On Site	None	No significant VOCs were detected in Quarry 3 sediment.
	Surface Water	Surface Water	Contact with Quarry 3 Surface Water; Adolescent Trespasser	Trespasser/Visitor	Adolescent (Teens)	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Water	Contact with Quarry 3 Surface Water; Adolescent Trespasser	Trespasser/Visitor	Adolescent (Teens)	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Water	Inhalation of Volatiles in Quarry 3 Surface Water; Adolescent Trespasser	Trespasser/Visitor	Adolescent (Teens)	Inhalation	On Site	None	No significant VOCs were detected in Quarry 3 surface water.
Future	Surface Soil	Surface Soil	Contact with Quarry 3 Surface Soil; Residential Child	Resident	Child	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Quarry 3 Surface Soil; Residential Child	Resident	Child	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 3 Surface Soil; Residential Child	Resident	Child	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 3 Surface Soil; Residential Child	Resident	Child	Inhalation	On Site	None	No significant VOCs were detected in Quarry 3 surface soil.
		Surface Soil	Contact with Quarry 3 Surface Soil; Residential Adult	Resident	Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Quarry 3 Surface Soil; Residential Adult	Resident	Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 3 Surface Soil; Residential Adult	Resident	Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 3 Surface Soil; Residential Adult	Resident	Adult	Inhalation	On Site	None	No significant VOCs were detected in Quarry 3 surface soil.
		Surface Soil	Contact with Quarry 3 Surface Soil; Lifetime Resident	Resident	Child/Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Quarry 3 Surface Soil; Lifetime Resident	Resident	Child/Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 3 Surface Soil; Lifetime Resident	Resident	Child/Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 3 Surface Soil; Lifetime Resident	Resident	Child/Adult	Inhalation	On Site	None	No significant VOCs were detected in Quarry 3 surface soil.
		Surface Soil	Contact with Quarry 3 Surface Soil; Industrial Worker	Industrial Worker	Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Quarry 3 Surface Soil; Industrial Worker	Industrial Worker	Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 3 Surface Soil; Industrial Worker	Industrial Worker	Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 3 Surface Soil; Industrial Worker	Industrial Worker	Adult	Inhalation	On Site	None	No significant VOCs were detected in Quarry 3 surface soil.
	Soil	Soil	Contact with Quarry 3 Soil (Surface and Subsurface); Construction Worker	Construction Worker	Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Soil	Contact with Quarry 3 Soil (Surface and Subsurface); Construction Worker	Construction Worker	Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 3 Soil (Surface and Subsurface); Construction Worker	Construction Worker	Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 3 Soil (Surface and Subsurface); Construction Worker	Construction Worker	Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
	Sediment	Sediment	Contact with Quarry 3 Sediment; Residential Child	Resident	Child	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Sediment	Contact with Quarry 3 Sediment; Residential Child	Resident	Child	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 3 Sediment; Residential Child	Resident	Child	Inhalation	On Site	None	Quarry 3 sediment is expected to be wet, resulting in no exposure
		Air	Inhalation of Volatiles in Quarry 3 Sediment; Residential Child	Resident	Child	Inhalation	On Site	None	No significant VOCs were detected in Quarry 3 sediment.
		Sediment	Contact with Quarry 3 Sediment; Residential Adult	Resident	Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Sediment	Contact with Quarry 3 Sediment; Residential Adult	Resident	Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 3 Sediment; Residential Adult	Resident	Adult	Inhalation	On Site	None	Quarry 3 sediment is expected to be wet, resulting in no exposure
		Air	Inhalation of Volatiles in Quarry 3 Sediment; Residential Adult	Resident	Adult	Inhalation	On Site	None	No significant VOCs were detected in Quarry 3 sediment.
		Sediment	Contact with Quarry 3 Sediment; Lifetime Resident	Resident	Child/Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Sediment	Contact with Quarry 3 Sediment; Lifetime Resident	Resident	Child/Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 3 Sediment; Lifetime Resident	Resident	Child/Adult	Inhalation	On Site	None	Quarry 3 sediment is expected to be wet, resulting in no exposure
		Air	Inhalation of Volatiles in Quarry 3 Sediment; Lifetime Resident	Resident	Child/Adult	Inhalation	On Site	None	No significant VOCs were detected in Quarry 3 sediment.
		Sediment	Contact with Quarry 3 Sediment; Industrial Worker	Industrial Worker	Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Sediment	Contact with Quarry 3 Sediment; Industrial Worker	Industrial Worker	Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 3 Sediment; Industrial Worker	Industrial Worker	Adult	Inhalation	On Site	None	Quarry 3 sediment is expected to be wet, resulting in no exposure
		Air	Inhalation of Volatiles in Quarry 3 Sediment; Industrial Worker	Industrial Worker	Adult	Inhalation	On Site	None	No significant VOCs were detected in Quarry 3 sediment.
	Surface Water	Surface Water	Contact with Quarry 3 Surface Water; Residential Child	Resident	Child	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Water	Contact with Quarry 3 Surface Water; Residential Child	Resident	Child	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 3 Surface Water; Residential Child	Resident	Child	Inhalation	On Site	None	No significant VOCs were detected in Quarry 3 surface water.
		Surface Water	Contact with Quarry 3 Surface Water; Residential Adult	Resident	Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Water	Contact with Quarry 3 Surface Water; Residential Adult	Resident	Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 3 Surface Water; Residential Adult	Resident	Adult	Inhalation	On Site	None	No significant VOCs were detected in Quarry 3 surface water.
		Surface Water	Contact with Quarry 3 Surface Water; Lifetime Resident	Resident	Child/Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Water	Contact with Quarry 3 Surface Water; Lifetime Resident	Resident	Child/Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 3 Surface Water; Lifetime Resident	Resident	Child/Adult	Inhalation	On Site	None	No significant VOCs were detected in Quarry 3 surface water.
		Surface Water	Contact with Quarry 3 Surface Water; Industrial Worker	Industrial Worker	Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Water	Contact with Quarry 3 Surface Water; Industrial Worker	Industrial Worker	Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 3 Surface Water; Industrial Worker	Industrial Worker	Adult	Inhalation	On Site	None	No significant VOCs were detected in Quarry 3 surface water.

T 1
SELECTION OF EXPO ATHWAYS - QUARRY 4
CRATER URCES

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Populations	Receptor Age	Exposure Routes	On Site/ Off Site	Type of Analysis	Rationale
Current	Surface Soil	Surface Soil	Contact with Quarry 4 Surface Soil; Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Quarry 4 Surface Soil; Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 4 Surface Soil; Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 4 Surface Soil; Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Inhalation	On Site	None	No significant VOCs were detected in Quarry 4 surface soil.
		Surface Soil	Contact with Quarry 4 Surface Soil; Industrial Worker	Industrial Worker	Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Quarry 4 Surface Soil; Industrial Worker	Industrial Worker	Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 4 Surface Soil; Industrial Worker	Industrial Worker	Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 4 Surface Soil; Industrial Worker	Industrial Worker	Adult	Inhalation	On Site	None	No significant VOCs were detected in Quarry 4 surface soil.
Future	Surface Soil	Surface Soil	Contact with Quarry 4 Surface Soil; Residential Child	Resident	Child	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Quarry 4 Surface Soil; Residential Child	Resident	Child	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 4 Surface Soil; Residential Child	Resident	Child	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 4 Surface Soil; Residential Child	Resident	Child	Inhalation	On Site	None	No significant VOCs were detected in Quarry 4 surface soil.
		Surface Soil	Contact with Quarry 4 Surface Soil; Residential Adult	Resident	Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Quarry 4 Surface Soil; Residential Adult	Resident	Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 4 Surface Soil; Residential Adult	Resident	Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 4 Surface Soil; Residential Adult	Resident	Adult	Inhalation	On Site	None	No significant VOCs were detected in Quarry 4 surface soil.
		Surface Soil	Contact with Quarry 4 Surface Soil; Lifetime Resident	Resident	Child/Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Quarry 4 Surface Soil; Lifetime Resident	Resident	Child/Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 4 Surface Soil; Lifetime Resident	Resident	Child/Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 4 Surface Soil; Lifetime Resident	Resident	Child/Adult	Inhalation	On Site	None	No significant VOCs were detected in Quarry 4 surface soil.
	Soil	Soil	Contact with Quarry 4 Soil (Surface and Subsurface); Construction Worker	Construction Worker	Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Soil	Contact with Quarry 4 Soil (Surface and Subsurface); Construction Worker	Construction Worker	Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 4 Soil (Surface and Subsurface); Construction Worker	Construction Worker	Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 4 Soil (Surface and Subsurface); Construction Worker	Construction Worker	Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.

TABLE 1
SELECTION OF EXPOSURE PATHWAYS - AREA 5
CRATER RESOURCES

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Populations	Receptor Age	Exposure Routes	On Site/ Off Site	Type of Analysis	Rationale
Current	Surface Soil	Surface Soil	Contact with Quarry 5 Surface Soil; Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Quarry 5 Surface Soil; Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 5 Surface Soil; Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 5 Surface Soil; Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Inhalation	On Site	None	No significant VOCs were detected in Quarry 5 surface soil.
		Surface Soil	Contact with Quarry 5 Surface Soil; Industrial Worker	Industrial Worker	Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Quarry 5 Surface Soil; Industrial Worker	Industrial Worker	Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 5 Surface Soil; Industrial Worker	Industrial Worker	Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 5 Surface Soil; Industrial Worker	Industrial Worker	Adult	Inhalation	On Site	None	No significant VOCs were detected in Quarry 5 surface soil.
Future	Surface Soil	Surface Soil	Contact with Quarry 5 Surface Soil; Residential Child	Resident	Child	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Quarry 5 Surface Soil; Residential Child	Resident	Child	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 5 Surface Soil; Residential Child	Resident	Child	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 5 Surface Soil; Residential Child	Resident	Child	Inhalation	On Site	None	No significant VOCs were detected in Quarry 5 surface soil.
		Surface Soil	Contact with Quarry 5 Surface Soil; Residential Adult	Resident	Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Quarry 5 Surface Soil; Residential Adult	Resident	Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 5 Surface Soil; Residential Adult	Resident	Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 5 Surface Soil; Residential Adult	Resident	Adult	Inhalation	On Site	None	No significant VOCs were detected in Quarry 5 surface soil.
		Surface Soil	Contact with Quarry 5 Surface Soil; Lifetime Resident	Resident	Child/Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Quarry 5 Surface Soil; Lifetime Resident	Resident	Child/Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 5 Surface Soil; Lifetime Resident	Resident	Child/Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 5 Surface Soil; Lifetime Resident	Resident	Child/Adult	Inhalation	On Site	None	No significant VOCs were detected in Quarry 5 surface soil.
	Soil	Soil	Contact with Quarry 5 Soil (Surface and Subsurface); Construction Worker	Construction Worker	Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Soil	Contact with Quarry 5 Soil (Surface and Subsurface); Construction Worker	Construction Worker	Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 5 Soil (Surface and Subsurface); Construction Worker	Construction Worker	Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 5 Soil (Surface and Subsurface); Construction Worker	Construction Worker	Adult	Inhalation	On Site	None	No significant VOCs were detected in Quarry 5 soil.

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TAPLE 1
SELECTION OF EXPO PATHWAYS - AREA 6
CRATER URCES

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Populations	Receptor Age	Exposure Routes	On Site/ Off Site	Type of Analysis	Rationale
Future	Soil	Soil	Contact with Quarry 6 Soil (Subsurface); Construction Worker	Construction Worker	Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Soil	Contact with Quarry 6 Soil (Subsurface); Construction Worker	Construction Worker	Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Quarry 6 Soil (Subsurface); Construction Worker	Construction Worker	Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Quarry 6 Soil (Subsurface); Construction Worker	Construction Worker	Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.

TABLE 1
SELECTION OF EXPOSURE PATHWAYS - YELLOW TRACT PIPELINE AREA
CRATER RESOURCES

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Populations	Receptor Age	Exposure Routes	On Site/ Off Site	Type of Analysis	Rationale
Current	Surface Soil	Surface Soil	Contact with Yellow Tract Pipeline Area Surface Soil; Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Yellow Tract Pipeline Area Surface Soil; Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Yellow Tract Pipeline Area Surface Soil; Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Yellow Tract Pipeline Area Surface Soil; Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Inhalation	On Site	None	No significant VOCs were detected in Yellow Tract PA surface soil.
	Sediment	Sediment	Contact with Yellow Tract Pipeline Area Sediment; Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Sediment	Contact with Yellow Tract Pipeline Area Sediment; Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Yellow Tract Pipeline Area Sediment; Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Inhalation	On Site	None	Yellow Tract PA sediment is expected to be wet, resulting in no exposure
		Air	Inhalation of Volatiles in Yellow Tract Pipeline Area Sediment; Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Inhalation	On Site	None	No significant VOCs were detected in Yellow Tract PA sediment.
Current/Future	Surface Soil	Surface Soil	Contact with Yellow Tract Pipeline Area Surface Soil; Industrial Worker	Industrial Worker	Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Yellow Tract Pipeline Area Surface Soil; Industrial Worker	Industrial Worker	Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Yellow Tract Pipeline Area Surface Soil; Industrial Worker	Industrial Worker	Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Yellow Tract Pipeline Area Surface Soil; Industrial Worker	Industrial Worker	Adult	Inhalation	On Site	None	No significant VOCs were detected in Yellow Tract PA surface soil.
	Sediment	Sediment	Contact with Yellow Tract Sediment; Industrial Worker	Industrial Worker	Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Sediment	Contact with Yellow Tract Sediment; Industrial Worker	Industrial Worker	Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Yellow Tract Sediment; Industrial Worker	Industrial Worker	Adult	Inhalation	On Site	None	Yellow Tract PA sediment is expected to be wet, resulting in no exposure
		Air	Inhalation of Volatiles in Yellow Tract Sediment; Industrial Worker	Industrial Worker	Adult	Inhalation	On Site	None	No significant VOCs were detected in Yellow Tract PA sediment.
Future	Surface Soil	Surface Soil	Contact with Yellow Tract Pipeline Area Surface Soil; Residential Child	Resident	Child	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Yellow Tract Pipeline Area Surface Soil; Residential Child	Resident	Child	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Yellow Tract Pipeline Area Surface Soil; Residential Child	Resident	Child	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Yellow Tract Pipeline Area Surface Soil; Residential Child	Resident	Child	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Yellow Tract Pipeline Area Surface Soil; Residential Adult	Resident	Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Yellow Tract Pipeline Area Surface Soil; Residential Adult	Resident	Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Yellow Tract Pipeline Area Surface Soil; Residential Adult	Resident	Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Yellow Tract Pipeline Area Surface Soil; Residential Adult	Resident	Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Yellow Tract Pipeline Area Surface Soil; Lifetime Resident	Resident	Child/Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Yellow Tract Pipeline Area Surface Soil; Lifetime Resident	Resident	Child/Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Yellow Tract Pipeline Area Surface Soil; Lifetime Resident	Resident	Child/Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Yellow Tract Pipeline Area Surface Soil; Lifetime Resident	Resident	Child/Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
	Sediment	Sediment	Contact with Yellow Tract Pipeline Area Sediment; Residential Child	Resident	Child	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Sediment	Contact with Yellow Tract Pipeline Area Sediment; Residential Child	Resident	Child	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Yellow Tract Pipeline Area Sediment; Residential Child	Resident	Child	Inhalation	On Site	None	Yellow Tract PA sediment is expected to be wet, resulting in no exposure
		Air	Inhalation of Volatiles in Yellow Tract Pipeline Area Sediment; Residential Child	Resident	Child	Inhalation	On Site	None	No significant VOCs were detected in Yellow Tract PA sediment.
		Sediment	Contact with Yellow Tract Pipeline Area Sediment; Residential Adult	Resident	Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Sediment	Contact with Yellow Tract Pipeline Area Sediment; Residential Adult	Resident	Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Yellow Tract Pipeline Area Sediment; Residential Adult	Resident	Adult	Inhalation	On Site	None	Yellow Tract PA sediment is expected to be wet, resulting in no exposure
		Air	Inhalation of Volatiles in Yellow Tract Pipeline Area Sediment; Residential Adult	Resident	Adult	Inhalation	On Site	None	No significant VOCs were detected in Yellow Tract PA sediment.
		Sediment	Contact with Yellow Tract Pipeline Area Sediment; Lifetime Resident	Resident	Child/Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Sediment	Contact with Yellow Tract Sediment; Lifetime Resident	Resident	Child/Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Yellow Tract Pipeline Area Sediment; Lifetime Resident	Resident	Child/Adult	Inhalation	On Site	None	Yellow Tract PA sediment is expected to be wet, resulting in no exposure
		Air	Inhalation of Volatiles in Yellow Tract Pipeline Area Sediment; Lifetime Resident	Resident	Child/Adult	Inhalation	On Site	None	No significant VOCs were detected in Yellow Tract PA sediment.

TA LE 1
SELECTION OF EXPOSURE PA S - YELLOW TRACT QUARRY 4
CRATE URCES

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Populations	Receptor Age	Exposure Routes	On Site/ Off Site	Type of Analysis	Rationale
Current	Sediment	Sediment	Contact with Yellow Tract Quarry 4 Sediment; Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Sediment	Contact with Yellow Tract Quarry 4 Sediment; Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Yellow Tract Quarry 4 Sediment; Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Inhalation	On Site	None	Yellow Tract Q4 sediment is expected to be wet, resulting in no exposure
		Air	Inhalation of Volatiles in Yellow Tract Quarry 4 Sediment; Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Inhalation	On Site	None	No significant VOCs were detected in Yellow Tract PA sediment.
Current/Future	Sediment	Sediment	Contact with Yellow Tract Sediment; Industrial Worker	Industrial Worker	Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Sediment	Contact with Yellow Tract Sediment; Industrial Worker	Industrial Worker	Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Yellow Tract Sediment; Industrial Worker	Industrial Worker	Adult	Inhalation	On Site	None	Yellow Tract Q4 sediment is expected to be wet, resulting in no exposure
		Air	Inhalation of Volatiles in Yellow Tract Sediment; Industrial Worker	Industrial Worker	Adult	Inhalation	On Site	None	No significant VOCs were detected in Yellow Tract Q4 sediment.
Future	Soil	Soil	Contact with Yellow Tract Quarry 4 Soil (Subsurface); Construction Worker	Construction Worker	Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Soil	Contact with Yellow Tract Quarry 4 Soil (Subsurface); Construction Worker	Construction Worker	Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Yellow Tract Quarry 4 Soil (Subsurface); Construction Worker	Construction Worker	Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Yellow Tract Quarry 4 Soil (Subsurface); Construction Worker	Construction Worker	Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
	Sediment	Sediment	Contact with Yellow Tract Quarry 4 Sediment; Residential Child	Resident	Child	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Sediment	Contact with Yellow Tract Quarry 4 Sediment; Residential Child	Resident	Child	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Yellow Tract Quarry 4 Sediment; Residential Child	Resident	Child	Inhalation	On Site	None	Yellow Tract Q4 sediment is expected to be wet, resulting in no exposure
		Air	Inhalation of Volatiles in Yellow Tract Quarry 4 Sediment; Residential Child	Resident	Child	Inhalation	On Site	None	No significant VOCs were detected in Yellow Tract Q4 sediment.
		Sediment	Contact with Yellow Tract Quarry 4 Sediment; Residential Adult	Resident	Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Sediment	Contact with Yellow Tract Quarry 4 Sediment; Residential Adult	Resident	Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Yellow Tract Quarry 4 Sediment; Residential Adult	Resident	Adult	Inhalation	On Site	None	Yellow Tract Q4 sediment is expected to be wet, resulting in no exposure
		Air	Inhalation of Volatiles in Yellow Tract Quarry 4 Sediment; Residential Adult	Resident	Adult	Inhalation	On Site	None	No significant VOCs were detected in Yellow Tract Q4 sediment.
		Sediment	Contact with Yellow Tract Quarry 4 Sediment; Lifetime Resident	Resident	Child/Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Sediment	Contact with Yellow Tract Sediment; Lifetime Resident	Resident	Child/Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Yellow Tract Quarry 4 Sediment; Lifetime Resident	Resident	Child/Adult	Inhalation	On Site	None	Yellow Tract Q4 sediment is expected to be wet, resulting in no exposure
		Air	Inhalation of Volatiles in Yellow Tract Quarry 4 Sediment; Lifetime Resident	Resident	Child/Adult	Inhalation	On Site	None	No significant VOCs were detected in Yellow Tract Q4 sediment.

TABLE 1
SELECTION OF EXPOSURE PATHWAYS - GROUNDWATER (3 PLUMES; CENTER, AREAL, AND SKB WELLS) AND MISCELLANEOUS EXPOSURE MEDIA (SS1 + SS2 & SS3)
CRATER RESOURCES

Scenario Timeframe	Medium	Exposure Medium	Exposure Point	Receptor Populations	Receptor Age	Exposure Routes	On Site/ Off Site	Type of Analysis	Rationale
Current	Surface Soil	Surface Soil	Contact with Surface Soil (SS-1 & SS-2; and SS-3); Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Surface Soil (SS-1 & SS-2; and SS-3); Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Surface Soil (SS-1 & SS-2; and SS-3); Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Surface Soil (SS-1 & SS-2; and SS-3); Adolescent Trespasser	Trespasser/Visitor	Adolescents (Teens)	Inhalation	On Site	None	No significant VOCs were detected in Surface Soil (SS-1 & SS-2, and SS-3).
		Surface Soil	Contact with Surface Soil (SS-1 & SS-2; and SS-3); Industrial Worker	Industrial Worker	Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Surface Soil (SS-1 & SS-2; and SS-3); Industrial Worker	Industrial Worker	Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Surface Soil (SS-1 & SS-2; and SS-3); Industrial Worker	Industrial Worker	Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Surface Soil (SS-1 & SS-2; and SS-3); Industrial Worker	Industrial Worker	Adult	Inhalation	On Site	None	No significant VOCs were detected in Surface Soil (SS-1 & SS-2; and SS-3).
Future	Surface Soil	Surface Soil	Contact with Surface Soil (SS-1 & SS-2; and SS-3); Residential Child	Resident	Child	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Surface Soil (SS-1 & SS-2; and SS-3); Residential Child	Resident	Child	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Surface Soil (SS-1 & SS-2; and SS-3); Residential Child	Resident	Child	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Surface Soil (SS-1 & SS-2; and SS-3); Residential Child	Resident	Child	Inhalation	On Site	None	No significant VOCs were detected in Surface Soil (SS-1 & SS-2; and SS-3).
		Surface Soil	Contact with Surface Soil (SS-1 & SS-2; and SS-3); Residential Adult	Resident	Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Surface Soil (SS-1 & SS-2; and SS-3); Residential Adult	Resident	Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Surface Soil (SS-1 & SS-2; and SS-3); Residential Adult	Resident	Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Surface Soil (SS-1 & SS-2; and SS-3); Residential Adult	Resident	Adult	Inhalation	On Site	None	No significant VOCs were detected in Surface Soil (SS-1 & SS-2; and SS-3).
		Surface Soil	Contact with Surface Soil (SS-1 & SS-2; and SS-3); Lifetime Resident	Resident	Child/Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Surface Soil	Contact with Surface Soil (SS-1 & SS-2; and SS-3); Lifetime Resident	Resident	Child/Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Particulates	Inhalation of Particulates in Surface Soil (SS-1 & SS-2; and SS-3); Lifetime Resident	Resident	Child/Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Surface Soil (SS-1 & SS-2; and SS-3); Lifetime Resident	Resident	Child/Adult	Inhalation	On Site	None	No significant VOCs were detected in Surface Soil (SS-1 & SS-2; and SS-3).
	Groundwater	Groundwater	Contact with Area Groundwater (3 Plumes); Residential Child	Resident	Child	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Groundwater	Contact with Area Groundwater (3 Plumes); Residential Child	Resident	Child	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Area Groundwater (3 Plumes); Residential Child	Resident	Child	Inhalation	On Site	None	Receptor activity patterns are not expected to result in significant exposure.
		Groundwater	Contact with Area Groundwater (3 Plumes); Residential Adult	Resident	Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Groundwater	Contact with Area Groundwater (3 Plumes); Residential Adult	Resident	Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Area Groundwater (3 Plumes); Residential Adult	Resident	Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Groundwater	Contact with Area Groundwater (3 Plumes); Lifetime Resident	Resident	Child/Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Groundwater	Contact with Area Groundwater (3 Plumes); Lifetime Resident	Resident	Child/Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Area Groundwater (3 Plumes); Lifetime Resident	Resident	Child/Adult	Inhalation	On Site	Quant	Receptor activity patterns could result in exposure.
		Groundwater	Contact with Area Groundwater (3 Plumes); Industrial Worker	Industrial Worker	Adult	Ingestion	On Site	Quant	Receptor activity patterns could result in exposure.
		Groundwater	Contact with Area Groundwater (3 Plumes); Industrial Worker	Industrial Worker	Adult	Dermal Absorption	On Site	Quant	Receptor activity patterns could result in exposure.
		Air	Inhalation of Volatiles in Area Groundwater (3 Plumes); Industrial Worker	Industrial Worker	Adult	Inhalation	On Site	None	Receptor activity patterns are not expected to result in exposure.
		Groundwater	Contact with Area Groundwater (3 Plumes); Construction Worker	Construction Worker	Adult	Ingestion	On Site	None	Groundwater (3 Plumes) is at a depth that is not expected to result in exposure.
		Groundwater	Contact with Area Groundwater (3 Plumes); Construction Worker	Construction Worker	Adult	Dermal Absorption	On Site	None	Groundwater (3 Plumes) is at a depth that is not expected to result in exposure.
		Air	Inhalation of Area Volatiles in Groundwater (3 Plumes); Construction Worker	Construction Worker	Adult	Inhalation	On Site	None	Groundwater (3 Plumes) is at a depth that is not expected to result in exposure.

TABLE 2

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Future

Medium: Groundwater

Exposure Medium: Groundwater

Exposure Point: Contact (Ing. & Der.) with Groundwater (Center of Plume); Residential Child

Chemical	Minimum Concentration	Maximum Concentration	Units	Location of Maximum Concentration	Detection Frequency	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
Arsenic	23.9	50.6	ug/L	MW-11S	2/6	30.1	ug/l	95% UCL-N
Barium	14.2	713	ug/l	MW-13S	6/6	713	ug/l	Max.
Beryllium	9.6	24.8	ug/L	MW-6	2/2	24.8	ug/l	Max.
Chromium	6.7	89.4	ug/L	MW-13S	4/6	89.4	ug/l	Max.
Cyanide	52.7	1120	ug/L	MW-13D	5/5	1120	ug/l	Max.
Iron	2570	65200	ug/L	MW-6	6/6	65200	ug/l	Max.
Lead	15.8	68	ug/L	MW-6	3/4	26.3	ug/l	Mean-N
Manganese	130	33600	ug/L	MW-13D	6/6	33600	ug/l	Max.
Selenium	10.5	97.7	ug/L	MW-6	5/6	97.7	ug/l	Max.
2,4-Dimethylphenol	20	580	ug/L	MW-11D	4/6	580	ug/l	Max.
2-Methylphenol	89	6300	ug/L	MW-13S	4/6	6300	ug/l	Max.
4-Methylphenol	2100	24000	ug/L	MW-13S	3/6	24000	ug/l	Max.
Dibenzofuran	1	16	ug/L	MW-11D	3/6	16	ug/l	Max.
Naphthalene	12	1300	ug/L	MW-11D	5/6	1300	ug/l	Max.
Phenol	10	19000	ug/L	MW-13S	5/6	19000	ug/l	Max.
Acetone	110	420	ug/L	MW-7	2/6	420	ug/l	Max.
Benzene	4	250	ug/L	MW-13S	5/6	250	ug/l	Max.
Chloroform	2.6	3.9	ug/L	MW-7	2/5	3.08	ug/l	95% UCL-N

Statistics: Maximum Detected Value (Max); 95% UCL of Normal Data (95% UCL-N); 95% UCL of Log-transformed Data (95% UCL-T); Mean of Log-transformed Data (Mean-T); Mean of Normal Data (Mean-N)

TABLE 2

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Future
Medium: Groundwater
Exposure Medium: Groundwater
Exposure Point: Contact (Ing. & Der.) with Groundwater (Extent of Plume); Residential Child

Chemical	Minimum Concentration	Maximum Concentration	Units	Location of Maximum Concentration	Detection Frequency	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
Arsenic	15.5	50.6	ug/L	MW-11S	6/18	33.1	ug/l	95%UCL-T
Barium	2.6	713	ug/L	MW-13S	22/22	498	ug/l	95%UCL-T
Beryllium	0.36	245	ug/L	MW-17D	9/17	245	ug/l	Max.
Cadmium	0.84	29.4	ug/L	MW-17D	5/17	5.08	ug/l	95%UCL-T
Chromium	5.3	205	ug/L	MW-16S	12/22	205	ug/l	Max.
Cobolt	5.6	1010	ug/L	MW-17D	12/12	384	ug/l	95%UCL-T
Cyanide	2.6	1120	ug/L	MW-13D	11/22	1120	ug/l	Max.
Iron	547	65200	ug/L	MW-6	23/23	56500	ug/l	95%UCL-T
Lead	6.5	499	ug/L	MW-17D	17/18	65.2	ug/l	Mean-T
Manganese	42.4	33600	ug/L	MW-13D	23/23	13300	ug/l	95%UCL-T
Mercury	0.11	4.3	ug/L	MW-17D	7/20	0.4	ug/l	95%UCL-T
Nickel	5.6	2380	ug/L	MW-17D	17/21	2380	ug/l	Max.
Selenium	4.9	152	ug/L	MW-8	7/19	42.6	ug/l	95%UCL-T
Thallium	11.3	11.3	ug/L	MW-17D	1/19	3.06	ug/l	95%UCL-T
Vanadium	1.6	41.8	ug/L	MW-16S	15/17	41.8	ug/l	Max.
Zinc	19.4	8110	ug/L	MW-17D	19/22	2950	ug/l	95%UCL-T
2-Methylphenol	0.6	6300	ug/L	MW-13S	6/23	1370	ug/l	95%UCL-T
4-Methylphenol	1	24000	ug/L	MW-13S	4/23	3470	ug/l	95%UCL-T
2,4-Dimethylphenol	20	580	ug/L	MW-11D	4/23	90.1	ug/l	95%UCL-T
Dibenzofuran	1	16	ug/L	MW-11D	3/23	7.07	ug/l	95%UCL-T
Naphthalene	4	1300	ug/L	MW-11D	6/23	81.2	ug/l	95%UCL-T
Acetone	5	420	ug/L	MW-7	4/13	420	ug/l	Max.
Benzene	0.23	250	ug/L	MW-13S	10/23	53.3	ug/l	95%UCL-T
Chloroform	0.12	3.9	ug/L	MW-7	9/22	1.94	ug/l	95%UCL-T

Statistics: Maximum Detected Value (Max); 95% UCL of Normal Data (95% UCL-N); 95% UCL of Log-transformed Data (95% UCL-T); Mean of Log-transformed Data (Mean-T); Mean of Normal Data (Mean-N).

TABLE 2

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Future

Medium: Soil

Exposure Medium: Soil/Air/Particulates

Exposure Point: Contact (Ing., Der. & Inhal.) with Soil (Quarry 1); Construction Worker

Chemical	Minimum Concentration	Maximum Concentration	Units	Detection Frequency	Location of Maximum Concentration	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
Soil								
Aluminum	7120	30500	mg/kg	12-Dec	Q1-1 (6-8)	21700	mg/kg	95% UCL-N
Particulates								
Manganese	229	2480	mg/kg	12/12	Q1-7 (79-79.4)	1080	mg/kg	95% UCL-N
Air								
Naphthalene	11000	3100000	ug/kg	2/8	Q1-6 (18-20)	3100000	ug/kg	Max.

TABLE 2

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Soil
Exposure Point: Contact (Ing. & Der.) with Soil and Particulates (Quarry 2); Construction Worker

Chemical	Minimum Concentration	Maximum Concentration	Units	Detection Frequency	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
Arsenic	1.2	18	mg/kg	11/11	18	mg/kg	Max.
Chromium	2.6	288	mg/kg	11/11	288	mg/kg	Max.
Iron	1240	143000	mg/kg	11/11	143000	mg/kg	Max.
Manganese	6.8	1530	mg/kg	11/11	1020	mg/kg	95% UCL-N

TABLE 2

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Medium: Soil

Exposure Medium: Soil

Exposure Point: Contact (Ing. & Der.) with Soil, Paticulates (Inh.) and Air (inh.) (Quarry 3); Construction Worker

Chemical	Minimum Concentration	Maximum Concentration	Units	Detection Frequency	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
Arsenic	11.7	660	mg/kg	13/13	660	mg/kg	Max.
Manganese	169	1140	mg/kg	13/13	756	mg/kg	95 % UCL-T
Mercury	0.23	49	mg/kg	11/11	49	mg/kg	Max.
Benzo(a)pyrene	540	470000	ug/kg	13/13	470000	ug/kg	Max.
Dibenz(a,h)anthracene	150	100000	ug/kg	11/13	100000	ug/kg	Max.
Naphthalene	3200	270000000	ug/kg	13/13	270000000	ug/kg	Max.

TABLE 2

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Future

Medium: Surface Soil

Exposure Medium: Surface Soil

Exposure Point: Contact (Ing. & Der.) and particualte (inh.) with Surface Soil (Quarry 3), Residential Child*

Chemical	Minimum Concentration	Maximum Concentration	Units	Detection Frequency	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
Aluminum	4570	26700	mg/kg	4/4	26700	mg/kg	Max.
Arsenic	17.7	302	mg/kg	4/4	302	mg/kg	Max.
Iron	21700	52500	mg/kg	4/4	52500	mg/kg	Max.
Mercury	0.23	22.5	mg/kg	4/4	22.5	mg/kg	Max.
Benz(a)anthracene	27000	400000	ug/kg	4/4	400000	ug/kg	Max.
Benzo(a)pyrene	38000	460000	ug/kg	4/4	460000	ug/kg	Max.
Benzo(b)fluoranthene	44000	630000	ug/kg	4/4	630000	ug/kg	Max.
Dibenz(a,h)anthracene	1800	100000	ug/kg	4/4	100000	ug/kg	Max.
Indeno(1,2,3-cd)pyrene	20000	330000	ug/kg	4/4	330000	ug/kg	Max.

* This screening is also valid for Future/Surface Soil/Particulates/Contact (Inhalation) with Particulates from Surface Soil (Quarry 3) Residential Child.
* This screening is also valid for Future/Surface Soil/Surface Soil/Contact (Ing. & Der.) with Surface Soil (Quarry 3) Residential Adult.
* This screening is also valid for Future/Surface Soil/Particulates/Contact (Inhalation) with Particulates from Surface Soil (Quarry 3) Residential Adult.
* This screening is also valid for Future/Surface Soil/Surface Soil/Contact (Ing. & Der.) with Surface Soil (Quarry 3) Lifetime Resident.
* This screening is also valid for Future/Surface Soil/Particulates/Contact (Inhalation) with Particulates from Surface Soil (Quarry 3) Lifetime Resident.
* This screening is also valid for Current/Surface Soil/Surface Soil/Contact (Ing. & Der.) with Surface Soil (Quarry 3) Adolescent Trespasser.
* This screening is also valid for Current/Surface Soil/Particulates/Contact (Inhalation) with Particulates from Surface Soil (Quarry 3) Adolescent Trespasser.
* This screening is also valid for Future/Surface Soil/Surface Soil/Contact (Ing. & Der.) with Surface Soil (Quarry 3) Industrial Adult.
* This screening is also valid for Future/Surface Soil/Particulates/Contact (Inhalation) with Particulates from Surface Soil (Quarry 3) Industrial Adult.

Statistics: Maximum Detected Value (Max); 95% UCL of Normal Data (95% UCL-N); 95% UCL of Log-transformed Data (95% UCL-T); Mean of Log-transformed Data (Mean-T); Mean of Normal Data (Mean-N).

TABLE 2

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Medium: Sediment

Exposure Medium: Sediment

Exposure Point: Contact (Ing. & Der.) with Sediment (Quarry 3); Residential Child*

Chemical	Minimum Concentration	Maximum Concentration	Units	Detection Frequency	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
Benz(a)anthracene	14000	2100000	ug/kg	13/14	2100000	ug/kg	Max.
Benzo(a)pyrene	16000	2500000	ug/kg	14/14	2500000	ug/kg	Max.
Benzo(b)fluoranthene	28000	3800000	ug/kg	14/14	3800000	ug/kg	Max.

* This screening is also valid for Future/Sediment/Sediment/Contact (Ing. & Der.) with Sediment (Quarry 3) Residential Adult.
* This screening is also valid for Future/Sediment/Sediment/Contact (Ing. & Der.) with Sediment (Quarry 3) Lifetime Resident.
* This screening is also valid for Current/Sediment/Sediment/Contact (Ing. & Der.) with Sediment (Quarry 3) Adolescent Trespasser.
* This screening is also valid for Future/Sediment/Sediment/Contact (Ing. & Der.) with Sediment (Quarry 3) Industrial Worker.

Statistics: Maximum Detected Value (Max); 95% UCL of Normal Data (95% UCL-N); 95% UCL of Log-transformed Data (95% UCL-T); Mean of Log-transformed Data (Mean-T); Mean of Normal Data (Mean-N).

TABLE 2
Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Future
Medium: Surface Soil
Exposure Medium: Surface Soil
Exposure Point: Contact (Ing. & Der.) with Surface Soil and Particulates (inh.) (Quarry 4); Residential Child*

Chemical	Minimum Concentration	Maximum Concentration	Units	Detection Frequency	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
Aluminum	8240	11600	mg/kg	2/2	11600	mg/kg	Max.
Arsenic	7	12.2	mg/kg	2/2	12.2	mg/kg	Max.
Chromium	20.8	331	mg/kg	2/2	331	mg/kg	Max.
Iron	23000	113000	mg/kg	2/2	113000	mg/kg	Max.
Manganese	678	6200	mg/kg	2/2	6200	mg/kg	Max.

* This screening is also valid for Future/Surface Soil/Particulates/Contact (Inhalation) with Particualtes from Surface Soil (Quarry 4) Residential Child.
* This screening is also valid for Future/Surface Soil/Surface Soil/Contact (Ing. & Der.) with Surface Soil (Quarry 4) Residential Adult.
* This screening is also valid for Future/Surface Soil/Particulates/Contact (Inhalation) with Particulates from Surface Soil (Quarry 4) Residential Adult.
* This screening is also valid for Future/Surface Soil/Surface Soil/Contact (Ing. & Der.) with Surface Soil (Quarry 4) Lifetime Resident.
* This screening is also valid for Future/Surface Soil/Particulates/Contact (Inhalation) with Particualtes from Surface Soil (Quarry 4) Lifetime Resident.
* This screening is also valid for Current/Surface Soil/Surface Soil/Contact (Ing. & Der.) with Surface Soil (Quarry 4) Adolescent Trespasser.
* This screening is also valid for Current/Surface Soil/Particulates/Contact (Inhalation) with Particulates from Surface Soil (Quarry 4) Adolescent Trespasser.
* This screening is also valid for Current/Surface Soil/Surface Soil/Contact (Ing. & Der.) with Surface Soil (Quarry 4) Industrial Adult.
* This screening is also valid for Current/Surface Soil/Particulates/Contact (Inhalation) with Particulates from Surface Soil (Quarry 4) Industrial Adult.

(1) Represents the 95% UCL of normal data for normal distributions; Represents the log-transformed 95% UCL for lognormal distributions.
Statistics: Maximum Detected Value (Max); 95% UCL of Normal Data (95% UCL-N); 95% UCL of Log-transformed Data (95% UCL-T);
Mean of Log-transformed Data (Mean-T); Mean of Normal Data (Mean-N).

TABLE 2
Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Medium: Surface Soil
Exposure Medium: Surface Soil
Exposure Point: Contact (Ing. & Der.) with Surface Soil and Particulates (inh.) (Quarry 4); Construction Worker

Chemical	Minimum Concentration	Maximum Concentration	Units	Detection Frequency	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
Aluminum	310	22600	mg/kg	8/8	22600	mg/kg	Max.
Manganese	5.4	6200	mg/kg	10/10	6200	mg/kg	Max.
Vanadium	10.5	2140	mg/kg	9/9	2140	mg/kg	Max.

TABLE 2
Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Soil
Exposure Point: Contact (Ing. & Der.) with Soil, Particulates (inh.) and Air (inh.) (Quarry 6); Construction Worker

Chemical	Minimum Concentration	Maximum Concentration	Units	Detection Frequency	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
Aluminum	1360	8170	ug/kg	2/2	8170	ug/kg	Max.
Iron	24900	31100	ug/kg	2/2	31100	ug/kg	Max.
Manganese	89.7	185	ug/kg	2/2	185	ug/kg	Max.
2-Methylnaphthalene	5000	5000	ug/kg	1/2	5000	ug/kg	Max.
4-Methylphenol	620	620	ug/kg	1/2	620	ug/kg	Max.
Benz(a)anthracene	520	8800000	ug/kg	2/2	8800000	ug/kg	Max.
Benzo(a)pyrene	470	8100000	ug/kg	2/2	8100000	ug/kg	Max.
Benzo(b)fluoranthene	5700000	5700000	ug/kg	1/2	5700000	ug/kg	Max.
Benzo(k)fluoranthene	5500000	5500000	ug/kg	1/2	5500000	ug/kg	Max.
Dibenz(a,h)anthracene	1600000	1600000	ug/kg	1/2	1600000	ug/kg	Max.
Dibenzofuran	7200000	7200000	ug/kg	1/2	7200000	ug/kg	Max.
Fluoranthene	1300	22000000	ug/kg	2/2	22000000	ug/kg	Max.
Flluorene	0.51	9600	ug/kg	2/2	9600	ug/kg	Max.
Indeno(1,2,3-cd)pyrene	4600000	4600000	ug/kg	1/2	4600000	ug/kg	Max.
Naphthalene	870	29000000	ug/kg	2/2	29000000	ug/kg	Max.
Pyrene	1500	23000000	ug/kg	2/2	23000000	ug/kg	Max.

TABLE 2

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Future
Medium: Surface Soil
Exposure Medium: Surface Soil
Exposure Point: Contact (Ing. & Der.) with Surface Soil (SS-1 + SS-2); Residential Child[a]

Chemical	Minimum Concentration	Maximum Concentration	Units	Location of Maximum Concentration	Detection Frequency	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
Aluminum	8060	9690	mg/kg	SS-2	2/2	9690	mg/kg	Max
Iron	36400	51700	mg/kg	SS-1	2/2	51700	mg/kg	Max
Manganese	482	1940	mg/kg	SS-1	2/2	1940	mg/kg	Max

[a] This screening also valid for Residential Adult, Lifetime Resident, Adolescent Trespasser, and Industrial Adult

TABLE 2

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Future
Medium: Surface Soil
Exposure Medium: Surface Soil
Exposure Point: Contact (Ing. & Der.) with Surface Soil (SS-3); Residential Child*

Chemical	Minimum Concentration	Maximum Concentration	Units	Location of Maximum Concentration	Detection Frequency	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
Arsenic	8.8	8.8	mg/kg	SS-3	1/1	8.8	mg/kg	Max
Iron	64900	64900	mg/kg	SS-3	1/1	64900	mg/kg	Max
Manganese	517	517	mg/kg	SS-3	1/1	517	mg/kg	Max
Benzo(a)pyrene	6600	6600	ug/kg	SS-3	1/1	6600	ug/kg	Max

* This screening also valid for Residential Adult, Lifetime Resident, Adolescent Trespasser, and Industrial Adult

TABLE 2

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Future
Medium: Surface Soil
Exposure Medium: Surface Soil
Exposure Point: Contact (Ing. & Der.) with Surface Soil (YP-Pipeline Area); Residential Child[a]

Chemical	Minimum Concentration	Maximum Concentration	Units	Location of Maximum Concentration	Detection Frequency	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
Aluminum	3390	27700	mg/kg	YUP-04	20/20	14700	mg/kg	95%UCL-T
Arsenic	4.5	146	mg/kg	YUP-04	20/20	28.8	mg/kg	95%UCL-T
Chromium	7.7	43.9	mg/kg	YUP-01	20/20	25.8	mg/kg	95%UCL-N
Cyanide	1.77	185	mg/kg	YUP-10	8/20	14.1	mg/kg	95%UCL-T
Iron	6070	54400	mg/kg	YSS-10	20/20	29,500	mg/kg	95%UCL-T
Benz(a)anthracene	68	430000	ug/kg	YUP-10	17/20	220,000	ug/kg	95%UCL-T
Benzo(a)pyrene	84	390000	ug/kg	YUP-10	18/20	25,700	ug/kg	95%UCL-T
Benzo(b)fluoranthene	52	420000	ug/kg	YUP-10	19/20	420,000	ug/kg	Max.
Dibenz(a,h)anthracene	48	48000	ug/kg	YUP-10	14/20	8720	ug/kg	95%UCL-T
Dibenzofuran	420000	420000	ug/kg	YUP-10	1/1	420000	ug/kg	Max.
Indeno(1,2,3-cd)pyrene	120	180000	ug/kg	YUP-10	18/20	62500	ug/kg	95%UCL-T

[a] This screening also valid for Residential Adult, Lifetime Resident, Adolescent Trespasser, and Industrial Adult

Statistics: Maximum Detected Value (Max); 95% UCL of Normal Data (95% UCL-N); 95% UCL of Log-transformed Data (95% UCL-T); Mean of Log-transformed Data (Mean-T); Mean of Normal Data (Mean-N).

TABLE 2

Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Scenario Timeframe: Future
Medium: Soil
Exposure Medium: Soil
Exposure Point: Contact (Ing. & Der.) with Soil (YP Quarry4); Construction Worker

Chemical	Minimum Concentration	Maximum Concentration	Units	Location of Maximum Concentration	Detection Frequency	Exposure Point Concentration	Exposure Point Concentration Units	Statistical Measure
Iron	20500	160000	mg/kg	SB-2-10-12	12/12	60000	mg/kg	95%UCL-T
Manganese	336	5280	mg/kg	Q4-T6-15	12/12	764	mg/kg	95%UCL-T

Statistics: 95% UCL of Log-transformed Data (95% UCL-T);

TABLE 3a
CANCER TOXICITY DATA -- ORAL/DERMAL

Chemical of Potential Concern	Oral Cancer Slope Factor	Adjusted Dermal Cancer Slope Factor (2)	Units	Weight of Evidence/ Cancer Guideline Description (4)	Source Target Organ	Date (3)
Aluminum	N/A	N/A	N/A	N/A	N/A	N/A
Arsenic	1.50E+00	1.58E+00	1/(mg/kg-day)	A	IRIS	04/15/99
Barium	N/A	N/A	N/A	N/A	N/A	N/A
Beryllium	N/A	N/A	N/A	N/A	N/A	N/A
Cadmium	N/A	N/A	N/A	N/A	N/A	N/A
Chromium	N/A	N/A	N/A	N/A	N/A	N/A
Cobalt	N/A	N/A	N/A	N/A	N/A	N/A
Cyanide	N/A	N/A	N/A	N/A	N/A	N/A
Iron	N/A	N/A	N/A	N/A	N/A	N/A
Lead	N/A	N/A	N/A	N/A	N/A	N/A
Manganese	N/A	N/A	N/A	N/A	N/A	N/A
Mercury	N/A	N/A	N/A	N/A	N/A	N/A
Nickel	N/A	N/A	N/A	N/A	N/A	N/A
Selenium	N/A	N/A	N/A	N/A	N/A	N/A
Thallium	N/A	N/A	N/A	N/A	N/A	N/A
Vanadium	N/A	N/A	N/A	N/A	N/A	N/A
Zinc	N/A	N/A	N/A	N/A	N/A	N/A
2,4-Dimethylphenol	N/A	N/A	N/A	N/A	N/A	N/A
2-Methylphenol	N/A	N/A	N/A	N/A	N/A	N/A
4-Methylphenol	N/A	N/A	N/A	N/A	N/A	N/A
Benz(a)anthracene	7.30E-01	N/A	1/(mg/kg-day)	B2	NCEA	03/01/93
Benzo(a)pyrene	7.30E+00	N/A	1/(mg/kg-day)	B2	IRIS	04/15/99
Benzo(b)fluoranthene	7.30E-01	N/A	1/(mg/kg-day)	B2	NCEA	03/01/93
Dibenz(a,h)anthracene	7.30E+00	N/A	1/(mg/kg-day)	B2	NCEA	03/01/93

TABLE 3a

CANCER TOXICITY DATA -- ORAL/DERMAL

Chemical of Potential Concern	Oral Cancer Slope Factor	Adjusted Dermal Cancer Slope Factor (2)	Units	Weight of Evidence/ Cancer Guideline Description (4)	Source Target Organ	Date (3)
Dibenzofuran	N/A	N/A	N/A	N/A	N/A	N/A
Fluoranthene	N/A	N/A	N/A	N/A	N/A	N/A
Fluorene	N/A	N/A	N/A	N/A	N/A	N/A
Indeno(1,2,3-cd)pyrene	7.30E-01	N/A	1/(mg/kg-day)	B2	NCEA	03/01/93
2-Methynaphthalene	N/A	N/A	N/A	N/A	N/A	N/A
Naphthalene	N/A	N/A	N/A	N/A	N/A	N/A
Phenol	N/A	N/A	N/A	N/A	N/A	N/A
Pyrene	N/A	N/A	N/A	N/A	N/A	N/A
Acetone	N/A	N/A	N/A	N/A	N/A	N/A
Benzene	2.90E-02	2.90E-02	1/(mg/kg-day)	A	IRIS	05/10/99
Chloroform	6.10E-03	6.10E-03	1/(mg/kg-day)	B2	IRIS	05/10/99

N/A = Not Applicable

(2) Adjusted SF dermal = oral SF/GI absorption value in toxicity study upon which the SF is based. To be used for dermal pathway only.

(3) IRIS - Integrated Risk Information System (EPA, 1999)
HEAST - Health Effects Assessment Summary Tables (EPA, 1997)

(4) EPA Group (Weight of Evidence); Weight of Evidence is only shown for those chemicals that have numerical cancer slope factors.

EPA Group:

A - Human carcinogen

B1 - Probable human carcinogen - Indicates that limited human data are available

B2 - Probable human carcinogen - Indicates sufficient evidence in animals and inadequate or no evidence in humans

C - Possible human carcinogen

D - Not classifiable as a human carcinogen

E - Evidence of noncarcinogenicity

TABLE 3b
CANCER TOXICITY DATA -- INHALATION

Chemical of Potential Concern	Inhalation Cancer Slope Factor	Units	Weight of Evidence/ Cancer Guideline Description (2)	Source	Date (1)
Aluminum	N/A	N/A	N/A	N/A	N/A
Arsenic	1.51E+01	1/(mg/kg-day)	A	IRIS	04/15/99
Beryllium	8.40E+00	1/(mg/kg-day)	B1	IRIS	05/18/99
Cadmium	6.3	1/(mg/kg-day)	B1	IRIS	05/10/99
Chromium	4.10E+01	1/(mg/kg-day)	A	IRIS	04/15/99
Cobalt	N/A	N/A	N/A	N/A	N/A
Cyanide	N/A	N/A	N/A	N/A	N/A
Iron	N/A	N/A	N/A	N/A	N/A
Lead	N/A	N/A	N/A	N/A	N/A
Manganese	N/A	N/A	N/A	N/A	N/A
Mercury	N/A	N/A	N/A	N/A	N/A
Nickel	N/A	N/A	N/A	N/A	N/A
Selenium	N/A	N/A	N/A	N/A	N/A
Thallium	N/A	N/A	N/A	N/A	N/A
Vanadium	N/A	N/A	N/A	N/A	N/A
Zinc	N/A	N/A	N/A	N/A	N/A
2,4-Dimethylphenol	N/A	N/A	N/A	N/A	N/A
2-Methylphenol	N/A	N/A	N/A	N/A	N/A
4-Methylphenol	N/A	N/A	N/A	N/A	N/A
Benz(a)anthracene	N/A	N/A	N/A	N/A	N/A
Benzo(a)pyrene	3.10E+00	1/(mg/kg-day)	B2	NCEA	11/18/97
Benzo(b)fluoranthene	N/A	N/A	N/A	N/A	N/A
Benzo(k)fluoranthene	N/A	N/A	N/A	N/A	N/A
Bis(2-ethylhexyl)phthalate	1.40E-02	1/(mg/kg-day)	B2	NCEA	08/02/93
Carbazole	N/A	N/A	N/A	N/A	N/A
Chrysene	N/A	N/A	N/A	N/A	N/A
Dibenz(a,h)anthracene	N/A	N/A	N/A	N/A	N/A

TABLE 3b
CANCER TOXICITY DATA -- INHALATION

Chemical of Potential Concern	Inhalation Cancer Slope Factor	Units	Weight of Evidence/ Cancer Guideline Description (2)	Source	Date (1)
Dibenzofuran	N/A	N/A	N/A	N/A	N/A
Fluoranthene	N/A	N/A	N/A	N/A	N/A
Fluorene	N/A	N/A	N/A	N/A	N/A
Indeno(1,2,3-cd)pyrene	N/A	N/A	N/A	N/A	N/A
2-Methylnaphthalene	N/A	N/A	N/A	N/A	N/A
Naphthalene	N/A	N/A	N/A	N/A	N/A
Phenol	N/A	N/A	N/A	N/A	N/A
Pyrene	N/A	N/A	N/A	N/A	N/A
Acetone	N/A	N/A	N/A	N/A	N/A
Benzene	2.90E-02	1/(mg/kg-day)	A	IRIS	05/10/99
Chloroform	8.10E-02	1/(mg/kg-day)	B2	IRIS	05/10/99
Tetrachloroethene	2.03E-03	1/(mg/kg-day)	B2-C	NCEA, Other	04/01/87

N/A = Not Applicable
(1) IRIS - Integrated Risk Information System (EPA, 1999)
HEAST - Health Effects Assessment Summary Tables (EPA, 1997)
(2) EPA Group (Weight of Evidence); Weight of Evidence is only shown for those chemicals that have numerical cancer slope factors.
A - Human carcinogen
B1 - Probable human carcinogen - indicates that limited human data are available
B2 - Probable human carcinogen - indicates sufficient evidence in animals and inadequate or no evidence in humans
C- Possilbe human carcinogen

TABLE 3c
NON-CANCER TOXICITY DATA -- ORAL/DERMAL

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD Value	Oral RfD Units	Adjusted Dermal RfD (2)	Units	Primary Target Organ	Combined Uncertainty/Modifying Factors	Sources of RfD: Target Organ	Dates of RfD: Target Organ (3)
Aluminum	Chronic	1.00E+00	mg/kg-day	2.70E-01	mg/kg-day	CNS (Developmental)	100	NCEA	08/26/96
Arsenic	Chronic	3.00E-04	mg/kg-day	2.85E-04	mg/kg-day	Skin/Vascular	3	IRIS	04/15/99
Barium	Chronic	7.00E-02	mg/kg-day	7.00E-02	mg/kg-day	Kidney	3	IRIS	09/29/98
Beryllium	Chronic	2.00E-03	mg/kg-day	2.00E-05	mg/kg-day	GI Tract	300	IRIS	05/10/99
Cadmium (Soil/Sediment)	Chronic	1.00E-03	mg/kg-day	2.50E-05	mg/kg-day	Kidney	10	IRIS	05/10/99
Cadmium (Water)	Chronic	5.00E-04	mg/kg-day	2.50E-05	mg/kg-day	Kidney	10	IRIS	05/10/99
Chromium	Chronic	3.00E-03	mg/kg-day	3.00E-05	mg/kg-day	Kidney	900	IRIS:Other	04/15/99
Cobalt	Chronic	6.00E-02	mg/kg-day	1.80E-02	mg/kg-day	Blood	1	NCEA	12/01/97
Cyanide	Chronic	2.00E-02	mg/kg-day	2.00E-02	mg/kg-day	Thyroid/Nervous System/Weight Loss	500	IRIS	05/10/99
Iron	Chronic	3.00E-01	mg/kg-day	3.00E-01	mg/kg-day	Liver/Blood/GI	1	NCEA	01/05/99
Lead	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Manganese	Chronic	2.40E-02	mg/kg-day	2.40E-02	mg/kg-day	CNS	3	IRIS	05/10/99
Mercury (4)	Chronic	1.00E-04	mg/kg-day	1.00E-04	mg/kg-day	CNS	10	IRIS	05/10/99
Nickel	Chronic	2.00E-02	mg/kg-day	2.00E-03	mg/kg-day	Decr. Org. Wt.	300	IRIS	05/10/99
Selenium	Chronic	5.00E-03	mg/kg-day	4.50E-03	mg/kg-day	Blood/Skin/CNS	3	IRIS	05/10/99
Thallium (5)	Chronic	7.00E-05	mg/kg-day	7.00E-05	mg/kg-day	Liver	3000	Other	04/12/99
Vanadium	Chronic	7.00E-03	mg/kg-day	1.40E-04	mg/kg-day	NOAEL	100	HEAST	07/01/97
Zinc	Chronic	3.00E-01	mg/kg-day	7.50E-02	mg/kg-day	Blood	3	IRIS	05/10/99
2,4-Dimethylphenol	Chronic	2.00E-02	mg/kg-day	2.00E-02	mg/kg-day	Blood/CNS	3000	IRIS	05/10/99
2-Methylphenol	Chronic	5.00E-02	mg/kg-day	5.00E-02	mg/kg-day	CNS/Weight Loss	1000	IRIS	05/10/99
4-Methylphenol	Chronic	5.00E-03	mg/kg-day	3.25E-03	mg/kg-day	CNS/Lung/Weight Loss	1000	HEAST	07/01/97
Benz(a)anthracene	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Benzo(a)pyrene	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Benzo(b)fluoranthene	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Dibenz(a,h)anthracene	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

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TABLE 3c

NON-CANCER TOXICITY DATA -- ORAL/DERMAL

Chemical of Potential Concern	Chronic/ Subchronic	Oral RfD Value	Oral RfD Units	Adjusted Dermal RfD (2)	Units	Primary Target Organ	Combined Uncertainty/Modifying Factors	Sources of RfD: Target Organ	Dates of RfD: Target Organ (3)
Dibenzofuran	Chronic	4.00E-03	mg/kg-day	2.80E-03	mg/kg-day	CNS/Weight Loss	3000	NCEA	04/12/93
Fluoranthene	Chronic	4.00E-02	mg/kg-day	2.80E-02	mg/kg-day	Kidney/Liver/Blood	3000	IRIS	05/10/99
Fluorene	Chronic	4.00E-02	mg/kg-day	2.80E-02	mg/kg-day	Blood	3000	IRIS	05/10/99
Indeno(1,2,3-cd)pyrene	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2-Methylnaphthalene	Chronic	2.00E-02	mg/kg-day	1.60E-02	mg/kg-day	Weight Loss	3000	NCEA	10/21/98
Naphthalene	Chronic	2.00E-02	mg/kg-day	1.60E-02	mg/kg-day	Weight Loss	3000	IRIS	05/10/99
Phenol	Chronic	6.00E-01	mg/kg-day	6.00E-01	mg/kg-day	Fetal Weight	100	IRIS	05/10/99
Pyrene	Chronic	3.00E-02	mg/kg-day	2.40E-02	mg/kg-day	Kidney	3000	IRIS	05/10/99
Acetone	Chronic	1.00E-01	mg/kg-day	8.30E-02	mg/kg-day	Liver/Kidney	1000	IRIS	05/10/99
Benzene	Chronic	3.00E-03	mg/kg-day	3.00E-03	mg/kg-day	Blood/Immune	3000	NCEA	07/02/96
Chloroform	Chronic	1.00E-02	mg/kg-day	1.00E-02	mg/kg-day	Liver	1000	IRIS	05/10/99
Tetrachloroethene	Chronic	1.00E-02	mg/kg-day	1.00E-02	mg/kg-day	Liver	1000	IRIS	05/10/99

N/A = Not Applicable

Acronyms: CNS = Central Nervous System; GI = Gastrointestinal Tract; and NOAEL = No Observed Adverse Effect Level.

(2) Adjusted RfD = oral RfD x GI absorption value in toxicity study upon which the RfD is based. To be used for dermal pathway only.

(3) IRIS - Integrated Risk Information System (EPA, 1999)
HEAST - Health Effects Assessment Summary Tables (EPA, 1997)

(4) Oral RfD for mercury is based on that for methyl mercury, the most conservative RfD for mercury compouds, because the actual form of mercury is not known.

(5) Oral RfD for thallium is based on that for thallic oxide, the most conservative RfD for thallium compouds, because the actual form of thallium is not known.

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TABLE 3d
NON-CANCER TOXICITY DATA – INHALATION

Chemical of Potential Concern	Chronic/ Subchronic	Adjusted Inhalation RfD	Units	Primary Target Organ	Combined Uncertainty/Modifying Factors	Sources of RfC:RfD: Target Organ	Dates (1)
Aluminum	Chronic	1.00E-03	mg/kg-day	CNS	300	NCEA	06/20/97
Arsenic	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Barium	Chronic	1.43E-04	mg/kg-day	Fetotoxicity	1000	HEAST	07/01/97
Beryllium	Chronic	5.70E-06	mg/kg-day	Respiratory/Immune	10	IRIS	05/18/99
Cadmium	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Chromium	Chronic	2.86E-05	mg/kg-day	Lung	300	IRIS	04/15/99
Cobalt	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Cyanide	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Iron	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Lead	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Manganese	Chronic	1.43E-05	mg/kg-day	CNS	1000	IRIS	05/10/99
Mercury	Chronic	8.60E-05	mg/kg-day	CNS	30	IRIS	05/10/99
Nickel	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Selenium	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Thallium	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Vanadium	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Zinc	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2,4-Dimethylphenol	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2-Methylphenol	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4-Methylphenol	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Benz(a)anthracene	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Benzo(a)pyrene	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Benzo(b)fluoranthene	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Dibenz(a,h)anthracene	N/A	N/A	N/A	N/A	N/A	N/A	N/A

TABLE 3d

NON-CANCER TOXICITY DATA -- INHALATION

Chemical of Potential Concern	Chronic/ Subchronic	Adjusted Inhalation RfD	Units	Primary Target Organ	Combined Uncertainty/Modifying Factors	Sources of RfC:RfD: Target Organ	Dates (1)
Dibenzofuran	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Fluoranthene	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Fluorene	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Indeno(1,2,3-cd)pyrene	N/A	N/A	N/A	N/A	N/A	N/A	N/A
2-Methylnaphthalene	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Naphthalene	Chronic	9.00E-04	mg/kg-day	Respiratory	3000	IRIS	05/10/99
Phenol	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Pyrene	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Acetone	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Benzene	Chronic	1.70E-03	mg/kg-day	Blood	1000	NCEA	07/02/96
Chloroform	Chronic	8.60E-05	mg/kg-day	Respiratory	1000	NCEA	12/01/97

N/A = Not Applicable

Acronyms: CNS = Central Nervous System

(1) IRIS - Integrated Risk Information System (EPA, 1999)

HEAST - Health Effects Assessment Summary Tables (EPA, 1997)

TABLE 4
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - CHILD RESIDENT EXPOSURE QUARRY 1 SURFACE SOIL AND GROUNDWATER (CENTER OF PLUME)
REASONABLE MAXIMUM EXPOSURE
CRATER RESOURCES

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Contact (Ing. & Der.) with Groundwater (Center of Plume)	Arsenic	2.88E-04	--	4.24E-07	2.89E-04	Arsenic	Skin/Vascular	7.48E+00	--	1.10E-02	7.49E+00
			Barium	--	--	--	--	Barium	Kidney	7.59E-01	--	1.00E-03	7.60E-01
			Beryllium	--	--	--	--	Beryllium	GI Tract	9.24E-01	--	1.29E-01	1.05E+00
			Chromium	--	--	--	--	Chromium	Kidney	2.22E+00	--	3.10E-01	2.53E+00
			Cyanide	--	--	--	--	Cyanide	Thyroid/Nervous System/Weight Los	4.17E+00	--	5.83E-03	4.18E+00
			Iron	--	--	--	--	Iron	Liver/Blood/GI Tract	1.62E+01	--	2.26E-02	1.62E+01
			Lead	--	--	--	--	Lead	N/A	--	--	--	--
			Manganese	--	--	--	--	Manganese	CNS	1.04E+02	--	1.40E-01	1.04E+02
			Selenium	--	--	--	--	Selenium	Blood/Skin/CNS	1.46E+00	--	2.26E-03	1.46E+00
			2,4-Dimethylphenol	--	--	--	--	2,4-Dimethylphenol	Blood/CNS	2.16E+00	--	1.52E-01	2.31E+00
			2-Methylphenol	--	--	--	--	2-Methylphenol	CNS/Weight Loss	9.39E+00	--	4.59E-01	9.85E+00
			4-Methylphenol	--	--	--	--	4-Methylphenol	CNS/Lung/Weight Loss	3.58E+02	--	2.68E+01	3.85E+02
			Dibenzofuran	--	--	--	--	Dibenzofuran	Kidney	2.98E-01	--	4.76E-01	7.74E-01
			Naphthalene	--	--	--	--	Naphthalene	Weight Loss	4.84E+00	--	2.35E+00	7.19E+00
			Phenol	--	--	--	--	Phenol	Fetal Weight	2.36E+00	--	6.70E-02	2.42E+00
			Acetone	--	--	--	--	Acetone	Liver/Kidney	3.13E-01	--	7.39E-04	3.14E-01
			Benzene	4.63E-05	--	3.83E-06	5.01E-05	Benzene	Blood/Immune	6.21E+00	--	5.14E-01	6.72E+00
			Chloroform	1.20E-07	--	5.60E-09	1.26E-07	Chloroform	Liver	2.30E-02	--	1.08E-03	2.40E-02
			(Total)	3.35E-04	--	4.26E-06	3.39E-04	(Total)		5.21E+02	--	3.15E+01	5.52E+02
Surface Soil	Surface Soil	Contact (Ing. & Der.) with Surface Soil (Quarry 1)	Iron*	--	--	--	--	Iron*	Liver/Blood/GI Tract	1.56E+00	--	7.31E-03	1.56E+00
			(Total)	--	--	--	--	(Total)		1.56E+00	--	7.31E-03	1.56E+00
	Particulates	Contact (Inh.) with Particulates from Surface Soil (Quarry 1)	Iron*	--	--	--	--	Iron*	N/A	--	--	--	--
			(Total)	--	--	--	--	(Total)		--	--	--	--

Total Risk Across Groundwater	3.39E-04
Total Risk Across Surface Soil	--
Total Risk Across All Media and All Exposure Routes	3.39E-04

Total Hazard Index Across Groundwater	5.52E+02
Total Hazard Index Across Surface Soil	1.56E+00
Total Hazard Index Across All Media and All Exposure Routes	5.54E+02

Total Blood HI =	2.83E+01
Total CNS HI =	5.03E+02
Total Fetal Weight HI =	2.42E+00
Total GI Tract HI =	1.88E+01
Total Immune HI =	6.72E+00
Total Kidney HI =	4.38E+00
Total Liver HI =	1.81E+01
Total Lung HI =	3.85E+02
Total Nervous System HI =	4.18E+00
Total Skin HI =	8.95E+00
Total Thyroid HI =	4.18E+00
Total Vascular HI =	7.49E+00
Total Weight Loss HI =	4.06E+02

Notes
* = Only the T-test for iron indicates a background exceedance.

TABLE 4
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - ADULT CONSTRUCTION WORKER EXPOSURE TO QUARRY 1 SOIL
REASONABLE MAXIMUM EXPOSURE
CRATER RESOURCES

Scenario Timeframe: Future
Receptor Population: Construction Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	Soil	Contact (Ing. & Der.) with Soil (Quarry 1)											
			Aluminum	--	--	--	--	Aluminum	CNS (Developmental)	6.36E-02	--	1.57E-03	6.52E-02
			Manganese	--	--	--	--	Manganese	CNS	1.32E-01	--	8.76E-04	1.33E-01
			Naphthalene	--	--	--	--	Naphthalene	Weight Loss	4.54E-01	--	3.77E-02	4.92E-01
			(Total)	--	--	--	--	(Total)		6.50E-01	--	4.02E-02	6.90E-01
	Air	Contact (Inh.) with Airborne Vapors from Soil (Quarry 1)											
			Naphthalene	--	--	--	--	Naphthalene	Respiratory	--	1.45E+00	--	1.45E+00
			(Total)	--	--	--	--	(Total)		--	1.45E+00	--	1.45E+00
	Particulates	Contact (Inh.) with Particulates from Soil (Quarry 1)											
			Aluminum	--	--	--	--	Aluminum	CNS	--	9.11E-01	--	9.11E-01
			Manganese	--	--	--	--	Manganese	CNS	--	3.17E+00	--	3.17E+00
			Naphthalene	--	--	--	--	Naphthalene	Respiratory	--	1.45E-01	--	1.45E-01
			(Total)	--	--	--	--	(Total)		--	4.23E+00	--	4.23E+00
						Total Risk Across Soil	--					Total Hazard Index Across Soil	6.36E+00
						Total Risk Across All Media and All Exposure Routes	--					Total Hazard Index Across All Media and All Exposure Routes	6.36E+00

Total CNS HI =	4.28E+00
Total CNS (Developmental) HI =	6.52E-02
Total Respiratory HI =	1.59E+00
Total Weight Loss HI =	4.92E-01

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TABLE 4
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - ADULT CONSTRUCTION WORKER EXPOSURE TO QUARRY 2 SOIL
REASONABLE MAXIMUM EXPOSURE
CRATER RESOURCES

Scenario Timeframe: Future
Receptor Population: Construction Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	Soil	Contact (Ing. & Der.) with Soil (Quarry 2)	Iron*	–	–	–	–	Iron*	Liver/Blood/GI Tract	1.40E+00	–	9.28E-03	1.41E+00
			Manganese*	–	–	–	–	Manganese*	CNS	1.25E-01	–	8.28E-04	1.25E-01
			(Total)	–	–	–	–	(Total)		1.52E+00	–	1.01E-02	1.53E+00
	Particulates	Contact (Inh.) with Particulates from Soil (Quarry 2)	Iron*	–	–	–	–	Iron*	N/A	–	–	–	–
			Manganese*	–	–	–	–	Manganese*	CNS	–	2.99E+00	–	2.99E+00
			(Total)	–	–	–	–	(Total)		–	2.99E+00	–	2.99E+00
						Total Risk Across Soil	–					Total Hazard Index Across Soil	4.53E+00
						Total Risk Across All Media and All Exposure Routes	–					Total Hazard Index Across All Media and All Exposure Routes	4.53E+00

Total Blood HI =	1.41E+00
Total CNS HI =	3.12E+00
Total Liver HI =	1.41E+00

Notes
* = Only the UTL test for iron and manganese indicates a background exceedance.

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TABLE 4

UMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - CHILD RESIDENT EXPOSURE TO QUARRY 3 SURFACE SOIL, SEDIMENT, SURFACE WATER AND GROUNDWATER (CENTER OF PLUME)

REASONABLE MAXIMUM EXPOSURE

CRATER RESOURCES

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk			
				Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Contact (Ing. & Der.) with Groundwater (Center of Plume)	Arsenic	2.88E-04	–	4.24E-07	2.88E-04
			Barium	–	–	–	–
			Beryllium	–	–	–	–
			Chromium	–	–	–	–
			Cyanide	–	–	–	–
			Iron	–	–	–	–
			Lead	–	–	–	–
			Manganese	–	–	–	–
			Selenium	–	–	–	–
			2,4-Dimethylphenol	–	–	–	–
			2-Methylphenol	–	–	–	–
			4-Methylphenol	–	–	–	–
			Dibenzofuran	–	–	–	–
			Naphthalene	–	–	–	–
			Phenol	–	–	–	–
			Acetone	–	–	–	–
			Benzene	4.63E-05	–	3.83E-06	5.01E-05
			Chloroform	1.20E-07	–	5.00E-09	1.28E-07
			(Total)	3.35E-04	–	4.26E-06	3.38E-04
Sediment	Sediment	Contact (Ing. & Der.) with Sediment (Quarry 3)	Benz(a)anthracene	6.67E-05	–	–	6.67E-05
			Benzo(a)pyrene	1.03E-03	–	–	1.03E-03
			Benzo(b)fluoranthene	1.57E-04	–	–	1.57E-04
			Dibenzofuran	–	–	–	–
			Naphthalene	–	–	–	–
			(Total)	1.26E-03	–	–	1.26E-03
Surface Soil	Surface Soil	Contact (Ing. & Der.) with Surface Soil (Quarry 3)	Aluminum*	–	–	–	–
			Arsenic	4.48E-04	–	7.10E-06	4.55E-04
			Iron*	–	–	–	–
			Mercury	–	–	–	–
			Benz(a)anthracene	2.89E-04	–	–	2.89E-04
			Benzo(a)pyrene	3.33E-03	–	–	3.33E-03
			Benzo(b)fluoranthene	4.55E-04	–	–	4.55E-04
			Dibenz(a,h)anthracene	7.23E-04	–	–	7.23E-04
			Indeno(1,2,3-cd)pyrene	2.30E-04	–	–	2.30E-04
			(Total)	5.48E-03	–	7.10E-06	5.49E-03
	Particulates	Contact (Inh.) with Particulates from Surface Soil (Quarry 3)	Aluminum*	–	–	–	–
			Arsenic	–	8.47E-05	–	8.47E-05
			Iron*	–	–	–	–
			Mercury	–	–	–	–
			Benz(a)anthracene	–	–	–	–
			Benzo(a)pyrene	–	2.65E-05	–	2.65E-05
			Benzo(b)fluoranthene	–	–	–	–
			Dibenz(a,h)anthracene	–	–	–	–
			Indeno(1,2,3-cd)pyrene	–	–	–	–
			(Total)	–	1.11E-04	–	1.11E-04

Total Risk Across Groundwater	3.38E-04
Total Risk Across Sediment	1.26E-03
Total Risk Across Surface Soil	5.60E-03
Total Risk Across Surface Water	–
Total Risk Across All Media and All Exposure Routes	7.21E-03

Chemical	Non-Carcinogenic Hazard Quotient				
	Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Arsenic	Skin/Vascular	7.48E+00	–	1.10E-02	7.49E+00
Barium	Kidney	7.59E-01	–	1.09E-03	7.60E-01
Beryllium	GI Tract	8.24E-01	–	1.28E-01	1.05E+00
Chromium	Kidney	2.22E+00	–	3.10E-01	2.53E+00
Cyanide	Thyroid/Nervous System/Weight Loss	4.17E+00	–	5.63E-03	4.18E+00
Iron	Liver/Blood/GI Tract	1.82E+01	–	2.28E-02	1.82E+01
Lead	N/A	–	–	–	–
Manganese	CNS	1.04E+02	–	1.48E-01	1.04E+02
Selenium	Blood/Skin/CNS	1.48E+00	–	2.28E-03	1.48E+00
2,4-Dimethylphenol	Blood/CNS	2.16E+00	–	1.52E-01	2.31E+00
2-Methylphenol	CNS/Weight Loss	8.39E+00	–	4.56E-01	8.85E+00
4-Methylphenol	CNS/Lung/Weight Loss	3.59E+02	–	2.68E+01	3.86E+02
Dibenzofuran	Kidney	2.98E-01	–	4.76E-01	7.74E-01
Naphthalene	Weight Loss	4.84E+00	–	2.30E+00	7.15E+00
Phenol	Fetal Weight	2.36E+00	–	6.70E-02	2.43E+00
Acetone	Liver/Kidney	3.13E-01	–	7.30E-04	3.14E-01
Benzene	Blood/Immune	8.21E+00	–	5.14E-01	8.72E+00
Chloroform	Liver	2.30E-02	–	1.09E-03	2.40E-02
(Total)		5.21E+02	–	3.15E+01	5.52E+02
Benz(a)anthracene	N/A	–	–	–	–
Benzo(a)pyrene	N/A	–	–	–	–
Benzo(b)fluoranthene	N/A	–	–	–	–
Dibenzofuran	Kidney	7.28E-01	–	3.73E-01	1.10E+00
Naphthalene	Weight Loss	1.22E+00	–	5.50E-01	1.77E+00
(Total)		1.95E+00	–	9.23E-01	2.87E+00
Aluminum*	CNS (Developmental)	3.09E-01	–	5.37E-03	3.14E-01
Arsenic	Skin/Vascular	1.16E+01	–	1.84E-01	1.18E+01
Iron*	Liver/Blood/GI Tract	2.02E+00	–	9.50E-03	2.03E+00
Mercury	CNS	2.60E+00	–	1.22E-02	2.61E+00
Benz(a)anthracene	N/A	–	–	–	–
Benzo(a)pyrene	N/A	–	–	–	–
Benzo(b)fluoranthene	N/A	–	–	–	–
Dibenz(a,h)anthracene	N/A	–	–	–	–
Indeno(1,2,3-cd)pyrene	N/A	–	–	–	–
(Total)		1.65E+01	–	2.11E-01	1.68E+01
Aluminum*	CNS	–	5.78E+00	–	5.78E+00
Arsenic	N/A	–	–	–	–
Iron*	N/A	–	–	–	–
Mercury	CNS	–	5.80E-02	–	5.80E-02
Benz(a)anthracene	N/A	–	–	–	–
Benzo(a)pyrene	N/A	–	–	–	–
Benzo(b)fluoranthene	N/A	–	–	–	–
Dibenz(a,h)anthracene	N/A	–	–	–	–
Indeno(1,2,3-cd)pyrene	N/A	–	–	–	–
(Total)		–	5.84E+00	–	5.84E+00

Total Hazard Index Across Groundwater	5.52E+02
Total Hazard Index Across Sediment	2.87E+00
Total Hazard Index Across Surface Soil	2.26E+01
Total Hazard Index Across Surface Water	–
Total Hazard Index Across All Media and All Exposure Routes	5.78E+02

Total Blood HI =	2.87E+01
Total CNS HI =	5.11E+02
Total CNS (Developmental) HI =	3.14E-01
Total Fetal Weight HI =	2.42E+00
Total GI Tract HI =	1.93E+01
Total Immune HI =	8.72E+00
Total Kidney HI =	5.49E+00
Total Liver HI =	1.86E+01
Total Lung HI =	3.85E+02
Total Nervous System HI =	4.18E+00
Total Skin HI =	2.08E+01
Total Thyroid HI =	4.18E+00
Total Vascular HI =	1.93E+01
Total Weight Loss HI =	4.08E+02

Notes

* = Only the UTL test for aluminum and iron indicates a background exceedance.

rc+three+thrad+threw+cp.xls

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SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - ADULT RESIDENT EXPOSURE [illegible]RY 3 SURFACE SOIL, SEDIMENT, SURFACE WATER AND GROUNDWATER (CENTER OF PLUME)
REASONABLE [illegible]UM EXPOSURE
CRATER RESOURCES

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk: Ingestion	Carcinogenic Risk: Inhalation	Carcinogenic Risk: Dermal	Carcinogenic Risk: Exposure Routes Total	Chemical	Non-Carcinogenic Hazard Quotient: Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Contact (Ing. & Der.) with Groundwater (Center of Plume)	Arsenic	4.30E-04	–	1.04E-05	[illegible]	Arsenic	Skin/Vascular	2.73E+00	–	[illegible]	2.7[illegible]E+00
			Barium	–	–	–	–	Barium	Kidney	2.78E-01	–	[illegible]	[illegible]
			Beryllium	–	–	–	–	Beryllium	GI Tract	3.40E-01	–	7.71E-02	4.17E-01
			Chromium	–	–	–	–	Chromium	Kidney	[illegible]	–	1.[illegible]	1.[illegible]
			Cyanide	–	–	–	–	Cyanide	Thyroid/Nervous System/Weight Loss	1.5[illegible]	–	[illegible]	1.5[illegible]
			Iron	–	–	–	–	Iron	Liver/Blood/GI Tract	[illegible]	–	[illegible]	[illegible]
			Lead	–	–	–	–	Lead	NA	–	–	–	–
			Manganese	–	–	–	–	Manganese	CNS	3.8[illegible]	–	[illegible]	[illegible]
			Selenium	–	–	–	–	Selenium	Blood/Skin/CNS	[illegible]	–	[illegible]	[illegible]
			2,4-Dimethylphenol	–	–	–	–	2,4-Dimethylphenol	Blood/CNS	[illegible]	–	[illegible]	[illegible]
			2-Methylphenol	–	–	–	–	2-Methylphenol	CNS/Weight Loss	[illegible]	–	2.74E-01	3.7[illegible]
			4-Methylphenol	–	–	–	–	4-Methylphenol	CNS/Lung/Weight Loss	1.3[illegible]	–	[illegible]	1.4[illegible]
			Dibenzofuran	–	–	–	–	Dibenzofuran	Kidney	3.1[illegible]	–	2.04E-01	3.9[illegible]
			Naphthalene	–	–	–	–	Naphthalene	Weight Loss	1.7[illegible]	–	[illegible]	2.7[illegible]
			Phenol	–	–	–	–	Phenol	Fetal Weight	[illegible]	–	3.44E-02	[illegible]
			Aniline	–	–	–	–	Aniline	Liver/Kidney	1.1[illegible]	–	4.1[illegible]	1.1[illegible]
			Benzene	[illegible]	–	4.7[illegible]	7.7[illegible]	Benzene	Blood/Immune	2.3[illegible]	–	1.0[illegible]	2.44E+00
			Chloroform	1.70E-07	–	[illegible]	1.[illegible]E-07	Chloroform	Liver	[illegible]	–	[illegible]	[illegible]
			(Total)	4.02E-04	–	3.01E-05	4.[illegible]E-04	(Total)		1.91E+02	–	1.82E+01	2.1[illegible]E+02
	Air	Contact (Inh.) with Airborne Vapor from Groundwater (Center of Plume)	Arsenic	–	NA	–	–	Arsenic	NA	–	–	–	–
			Barium	–	–	–	–	Barium	Fetotoxicity	–	NA	–	–
			Beryllium	–	NA	–	–	Beryllium	Respiratory/Immune	–	NA	–	–
			Chromium	–	NA	–	–	Chromium	Lung	–	NA	–	–
			Cyanide	–	–	–	–	Cyanide	NA	–	–	–	–
			Iron	–	–	–	–	Iron	NA	–	–	–	–
			Lead	–	–	–	–	Lead	NA	–	–	–	–
			Manganese	–	–	–	–	Manganese	CNS	–	NA	–	–
			Selenium	–	–	–	–	Selenium	NA	–	–	–	–
			2,4-Dimethylphenol	–	–	–	–	2,4-Dimethylphenol	NA	–	–	–	–
			2-Methylphenol	–	–	–	–	2-Methylphenol	NA	–	–	–	–
			4-Methylphenol	–	–	–	–	4-Methylphenol	NA	–	–	–	–
			Dibenzofuran	–	–	–	–	Dibenzofuran	NA	–	–	–	–
			Naphthalene	–	–	–	–	Naphthalene	Respiratory	–	4.4[illegible]	–	4.4[illegible]
			Phenol	–	–	–	–	Phenol	NA	–	–	–	–
			Aniline	–	–	–	–	Aniline	NA	–	–	–	–
			Benzene	–	1.2[illegible]	–	1.2[illegible]	Benzene	Blood	–	7.4[illegible]	–	7.4[illegible]
			Chloroform	–	[illegible]	–	[illegible]	Chloroform	Respiratory	–	1.[illegible]	–	1.[illegible]
			(Total)	–	1.2[illegible]	–	1.2[illegible]	(Total)		–	[illegible]	–	[illegible]
Sediment	Sediment	Contact (Ing. & Der.) with Sediment (Quarry 3)	Benzo(a)anthracene	2.[illegible]	–	–	2.[illegible]	Benzo(a)anthracene	NA	–	–	–	–
			Benzo(a)pyrene	2.4[illegible]	–	–	2.4[illegible]	Benzo(a)pyrene	NA	–	–	–	–
			Benzo(b)fluoranthene	3.72E-05	–	–	3.72E-05	Benzo(b)fluoranthene	NA	–	–	–	–
			Dibenzofuran	–	–	–	–	Dibenzofuran	Kidney	4.3[illegible]	–	[illegible]	1.0[illegible]
			Naphthalene	–	–	–	–	Naphthalene	Weight Loss	7.2[illegible]	–	[illegible]	1.[illegible]
			(Total)	3.0[illegible]	–	–	3.0[illegible]	(Total)		1.1[illegible]	–	1.5[illegible]	2.67E-01
Surface Soil	Surface Soil	Contact (Ing. & Der.) with Surface Soil (Quarry 3)	Aluminum*	–	–	–	–	Aluminum*	CNS (Developmental)	[illegible]	–	[illegible]	3.7[illegible]
			Arsenic	2.1[illegible]	–	[illegible]	2.1[illegible]	Arsenic	Skin/Vascular	1.3[illegible]	–	3.3[illegible]	1.4[illegible]
			Iron*	–	–	–	–	Iron*	Liver/Blood/GI Tract	2.4[illegible]	–	1.7[illegible]	2.4[illegible]
			Mercury	–	–	–	–	Mercury	CNS	3.[illegible]	–	2.1[illegible]	3.1[illegible]
			Benzo(a)anthracene	1.3[illegible]	–	–	1.3[illegible]	Benzo(a)anthracene	NA	–	–	–	–
			Benzo(a)pyrene	1.[illegible]	–	–	1.[illegible]	Benzo(a)pyrene	NA	–	–	–	–
			Benzo(b)fluoranthene	2.1[illegible]	–	–	2.1[illegible]	Benzo(b)fluoranthene	NA	–	–	–	–
			Dibenz(a,h)anthracene	2.4[illegible]	–	–	2.4[illegible]	Dibenz(a,h)anthracene	NA	–	–	–	–
			Indeno(1,2,3-cd)pyrene	1.1[illegible]	–	–	1.1[illegible]	Indeno(1,2,3-cd)pyrene	NA	–	–	–	–
			(Total)	2.[illegible]E-03	–	[illegible]	2.[illegible]E-03	(Total)		1.[illegible]	–	3.7[illegible]	2.[illegible]
	Particulates	Contact (Inh.) with Particulates from Surface Soil (Quarry 3)	Aluminum*	–	–	–	–	Aluminum*	CNS	–	1.[illegible]	–	1.[illegible]
			Arsenic	–	1.1[illegible]	–	1.1[illegible]	Arsenic	NA	–	–	–	–
			Iron*	–	–	–	–	Iron*	NA	–	–	–	–
			Mercury	–	–	–	–	Mercury	CNS	–	1.[illegible]	–	1.[illegible]
			Benzo(a)anthracene	–	–	–	–	Benzo(a)anthracene	NA	–	–	–	–
			Benzo(a)pyrene	–	3.4[illegible]	–	3.4[illegible]	Benzo(a)pyrene	NA	–	–	–	–
			Benzo(b)fluoranthene	–	–	–	–	Benzo(b)fluoranthene	NA	–	–	–	–
			Dibenz(a,h)anthracene	–	–	–	–	Dibenz(a,h)anthracene	NA	–	–	–	–
			Indeno(1,2,3-cd)pyrene	–	–	–	–	Indeno(1,2,3-cd)pyrene	NA	–	–	–	–
			(Total)	–	1.4[illegible]	–	1.4[illegible]	(Total)		–	1.[illegible]	–	1.[illegible]

Total Risk Across Groundwater	4.27E-04
Total Risk Across Sediment	3.03E-04
Total Risk Across Surface Soil	2.73E-03
Total Risk Across Surface Water	–
Total Risk Across All Media and All Exposure Routes	3.[illegible]E-03

Total Hazard Index Across Groundwater	2.0[illegible]E+02
Total Hazard Index Across Sediment	2.67E-01
Total Hazard Index Across Surface Soil	3.92E+00
Total Hazard Index Across Surface Water	–
Total Hazard Index Across All Media and All Exposure Routes	2.0[illegible]E+02

Total Blood HI =	1.73E+01
Total CNS HI =	1.83E+02
Total CNS (Developmental) HI =	3.73E-02
Total Fetal Weight HI =	9.02E-01
Total Fetotoxicity HI =	–
Total GI Tract HI =	6.63E+00
Total Immune HI =	2.44E+00
Total Kidney HI =	1.9[illegible]E+00
Total Liver HI =	6.33E+00
Total Lung HI =	1.48E+02
Total Nervous System HI =	1.54E+00
Total Respiratory HI =	4.6[illegible]E+01
Total Skin HI =	4.70E+00
Total Thyroid HI =	1.54E+00
Total Vascular HI =	4.17E+00
Total Weight Loss HI =	1.98E+02

Notes:
* = Only the UTL used for aluminum and iron indicates a background comparison.

TABLE 4
UMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - LIFETIME RESIDENT EXPOSURE TO QUARRY 3 SURFACE SOIL, SEDIMENT, SURFACE WATER AND GROUNDWATER (CENTER OF PLUME
REASONABLE MAXIMUM EXPOSURE
CRATER RESOURCES

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Contact (Ing. & Der.) with Groundwater (Center of Plume											
			Arsenic	7.12E-04	--	1.44E-05	7.14E-04	Arsenic	NA	NA	--	NA	--
			Barium	--	--	--	--	Barium	NA	NA	--	NA	--
			Beryllium	--	--	--	--	Beryllium	NA	NA	--	NA	--
			Chromium	--	--	--	--	Chromium	NA	NA	--	NA	--
			Cyanide	--	--	--	--	Cyanide	NA	NA	--	NA	--
			Iron	--	--	--	--	Iron	NA	NA	--	NA	--
			Lead	--	--	--	--	Lead	NA	NA	--	NA	--
			Manganese	--	--	--	--	Manganese	NA	NA	--	NA	--
			Selenium	--	--	--	--	Selenium	NA	NA	--	NA	--
			2,4-Dimethylphenol	--	--	--	--	2,4-Dimethylphenol	NA	NA	--	NA	--
			2-Methylphenol	--	--	--	--	2-Methylphenol	NA	NA	--	NA	--
			4-Methylphenol	--	--	--	--	4-Methylphenol	NA	NA	--	NA	--
			Dibenzofuran	--	--	--	--	Dibenzofuran	NA	NA	--	NA	--
			Naphthalene	--	--	--	--	Naphthalene	NA	NA	--	NA	--
			Phenol	--	--	--	--	Phenol	NA	NA	--	NA	--
			Acetone	--	--	--	--	Acetone	NA	NA	--	NA	--
			Benzene	1.14E-04	--	8.62E-06	1.23E-04	Benzene	NA	NA	--	NA	--
			Chloroform	2.08E-07	--	1.37E-08	3.10E-07	Chloroform	NA	NA	--	NA	--
			(Total)	8.27E-04	--	1.01E-05	8.37E-04	(Total)		--	--	--	--
	Air	Contact (Inh.) with Airborne Vapors from Groundwater (Center of Plume)											
			Arsenic	--	--	--	--	Arsenic	NA	--	NA	--	--
			Barium	--	--	--	--	Barium	NA	--	NA	--	--
			Beryllium	--	--	--	--	Beryllium	NA	--	NA	--	--
			Chromium	--	--	--	--	Chromium	NA	--	NA	--	--
			Cyanide	--	--	--	--	Cyanide	NA	--	NA	--	--
			Iron	--	--	--	--	Iron	NA	--	NA	--	--
			Lead	--	--	--	--	Lead	NA	--	NA	--	--
			Manganese	--	--	--	--	Manganese	NA	--	NA	--	--
			Selenium	--	--	--	--	Selenium	NA	--	NA	--	--
			2,4-Dimethylphenol	--	--	--	--	2,4-Dimethylphenol	NA	--	NA	--	--
			2-Methylphenol	--	--	--	--	2-Methylphenol	NA	--	NA	--	--
			4-Methylphenol	--	--	--	--	4-Methylphenol	NA	--	NA	--	--
			Dibenzofuran	--	--	--	--	Dibenzofuran	NA	--	NA	--	--
			Naphthalene	--	--	--	--	Naphthalene	NA	--	NA	--	--
			Phenol	--	--	--	--	Phenol	NA	--	NA	--	--
			Acetone	--	--	--	--	Acetone	NA	--	NA	--	--
			Benzene	--	1.26E-04	--	1.26E-04	Benzene	NA	--	NA	--	--
			Chloroform	--	3.85E-06	--	3.85E-06	Chloroform	NA	--	NA	--	--
			(Total)	--	1.29E-04	--	1.29E-04	(Total)		--	--	--	--
Sediment	Sediment	Contact (Ing. & Der.) with Sediment (Quarry 3)											
			Benzo(a)anthracene	1.07E-04	--	--	1.07E-04	Benzo(a)anthracene	NA	NA	--	NA	--
			Benzo(a)pyrene	1.28E-03	--	--	1.28E-03	Benzo(a)pyrene	NA	NA	--	NA	--
			Benzo(b)fluoranthene	1.94E-04	--	--	1.94E-04	Benzo(b)fluoranthene	NA	NA	--	NA	--
			Dibenzofuran	--	--	--	--	Dibenzofuran	NA	NA	--	NA	--
			Naphthalene	--	--	--	--	Naphthalene	NA	NA	--	NA	--
			(Total)	1.59E-03	--	--	1.59E-03	(Total)		--	--	--	--
Surface Soil	Surface Soil	Contact (Ing. & Der.) with Surface Soil (Quarry 3)											
			Aluminum*	--	--	--	--	Aluminum*	NA	NA	--	NA	--
			Arsenic	6.61E-04	--	1.22E-05	6.74E-04	Arsenic	NA	NA	--	NA	--
			Iron*	--	--	--	--	Iron*	NA	NA	--	NA	--
			Mercury	--	--	--	--	Mercury	NA	NA	--	NA	--
			Benzo(a)anthracene	4.28E-04	--	--	4.28E-04	Benzo(a)anthracene	NA	NA	--	NA	--
			Benzo(a)pyrene	4.90E-03	--	--	4.90E-03	Benzo(a)pyrene	NA	NA	--	NA	--
			Benzo(b)fluoranthene	6.71E-04	--	--	6.71E-04	Benzo(b)fluoranthene	NA	NA	--	NA	--
			Dibenz(a,h)anthracene	1.67E-03	--	--	1.67E-03	Dibenz(a,h)anthracene	NA	NA	--	NA	--
			Indeno(1,2,3-cd)pyrene	3.52E-04	--	--	3.52E-04	Indeno(1,2,3-cd)pyrene	NA	NA	--	NA	--
			(Total)	8.08E-03	--	1.22E-05	8.09E-03	(Total)		--	--	--	--
	Particulates	Contact (Inh.) with Particulates from Surface Soil (Quarry 3)											
			Aluminum*	--	--	--	--	Aluminum*	NA	--	NA	--	--
			Arsenic	--	1.96E-04	--	1.96E-04	Arsenic	NA	--	NA	--	--
			Iron*	--	--	--	--	Iron*	NA	--	NA	--	--
			Mercury	--	--	--	--	Mercury	NA	--	NA	--	--
			Benzo(a)anthracene	--	--	--	--	Benzo(a)anthracene	NA	--	NA	--	--
			Benzo(a)pyrene	--	6.13E-05	--	6.13E-05	Benzo(a)pyrene	NA	--	NA	--	--
			Benzo(b)fluoranthene	--	--	--	--	Benzo(b)fluoranthene	NA	--	NA	--	--
			Dibenz(a,h)anthracene	--	--	--	--	Dibenz(a,h)anthracene	NA	--	NA	--	--
			Indeno(1,2,3-cd)pyrene	--	--	--	--	Indeno(1,2,3-cd)pyrene	NA	--	NA	--	--
			(Total)	--	2.58E-04	--	2.58E-04	(Total)		--	--	--	--

Total Risk Across Groundwater	9.66E-04
Total Risk Across Sediment	1.59E-03
Total Risk Across Surface Soil	8.35E-03
Total Risk Across Surface Water	--
Total Risk Across All Media and All Exposure Routes	1.08E-02

Total Hazard Index Across Groundwater	--
Total Hazard Index Across Sediment	--
Total Hazard Index Across Surface Soil	--
Total Hazard Index Across Surface Water	--
Total Hazard Index Across All Media and All Exposure Routes	--

Notes:
* = Only the UTL test for aluminum and iron indicates a background exceedance.

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TABLE 4

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - ADOLESCENT (TEENS) TRESPASSER/VISITOR EXPOSURE TO QUARRY 3 SURFACE SOIL, SEDIMENT, AND SURFACE WATER

REASONABLE MAXIMUM EXPOSURE

CRATER RESOURCES

Scenario Timeframe: Current
Receptor Population: Trespasser/Visitor
Receptor Age: Adolescent (Teens)

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Sediment	Sediment	Contact (Ing. & Der.) with Sediment (Quarry 3)											
			Benz(a)anthracene	1.27E-05	–	–	1.27E-05	Benz(a)anthracene	N/A	–	–	–	–
			Benzo(a)pyrene	1.51E-04	–	–	1.51E-04	Benzo(a)pyrene	N/A	–	–	–	–
			Benzo(b)fluoranthene	2.30E-05	–	–	2.30E-05	Benzo(b)fluoranthene	N/A	–	–	–	–
			Dibenzofuran	–	–	–	–	Dibenzofuran	Kidney	6.38E-02	–	1.32E-01	1.95E-01
			Naphthalene	–	–	–	–	Naphthalene	Weight Loss	1.07E-01	–	1.94E-01	3.01E-01
			(Total)	1.87E-04	–	–	1.87E-04	(Total)		1.71E-01	–	3.25E-01	4.97E-01
Surface Soil	Surface Soil	Contact (Ing. & Der.) with Surface Soil (Quarry 3)											
			Aluminum*	–	–	–	–	Aluminum*	CNS (Developmental)	1.24E-02	–	6.66E-04	1.31E-02
			Arsenic	3.01E-05	–	1.47E-06	3.15E-05	Arsenic	Skin/Vascular	4.67E-01	–	2.28E-02	4.90E-01
			Iron*	–	–	–	–	Iron*	Liver/Blood/GI Tract	8.13E-02	–	1.16E-03	8.24E-02
			Mercury	–	–	–	–	Mercury	CNS	1.04E-01	–	1.51E-03	1.06E-01
			Benz(a)anthracene	1.94E-05	–	–	1.94E-05	Benz(a)anthracene	N/A	–	–	–	–
			Benzo(a)pyrene	2.23E-04	–	–	2.23E-04	Benzo(a)pyrene	N/A	–	–	–	–
			Benzo(b)fluoranthene	3.05E-05	–	–	3.05E-05	Benzo(b)fluoranthene	N/A	–	–	–	–
			Dibenz(a,h)anthracene	4.84E-05	–	–	4.84E-05	Dibenz(a,h)anthracene	N/A	–	–	–	–
			Indeno(1,2,3-cd)pyrene	1.60E-05	–	–	1.60E-05	Indeno(1,2,3-cd)pyrene	N/A	–	–	–	–
			(Total)	3.67E-04	–	1.47E-06	3.69E-04	(Total)		6.66E-01	–	2.62E-02	6.92E-01
	Particulates	Contact (Inh.) with Particulates from Surface Soil (Quarry 3)											
			Aluminum*	–	–	–	–	Aluminum*	CNS	–	1.55E-01	–	1.55E-01
			Arsenic	–	3.78E-08	–	3.78E-08	Arsenic	N/A	–	–	–	–
			Iron*	–	–	–	–	Iron*	N/A	–	–	–	–
			Mercury	–	–	–	–	Mercury	CNS	–	1.52E-03	–	1.52E-03
			Benz(a)anthracene	–	–	–	–	Benz(a)anthracene	N/A	–	–	–	–
			Benzo(a)pyrene	–	1.18E-08	–	1.18E-08	Benzo(a)pyrene	N/A	–	–	–	–
			Benzo(b)fluoranthene	–	–	–	–	Benzo(b)fluoranthene	N/A	–	–	–	–
			Dibenz(a,h)anthracene	–	–	–	–	Dibenz(a,h)anthracene	N/A	–	–	–	–
			Indeno(1,2,3-cd)pyrene	–	–	–	–	Indeno(1,2,3-cd)pyrene	N/A	–	–	–	–
			(Total)	–	4.96E-08	–	4.96E-08	(Total)		–	1.57E-01	–	1.57E-01

Total Risk Across Sediment	1.87E-04
Total Risk Across Surface Soil	3.74E-04
Total Risk Across Surface Water	–
Total Risk Across All Media and All Exposure Routes	5.61E-04

Total Hazard Index Across Sediment	4.97E-01
Total Hazard Index Across Surface Soil	8.48E-01
Total Hazard Index Across Surface Water	–
Total Hazard Index Across All Media and All Exposure Routes	1.34E+00

Total Blood HI =	8.24E-02
Total CNS HI =	2.76E-01
Total CNS (Developmental) HI =	1.31E-02
Total GI Tract HI =	8.24E-02
Total Kidney HI =	1.95E-01
Total Liver HI =	8.24E-02
Total Skin HI =	4.90E-01
Total Vascular HI =	4.90E-01
Total Weight Loss HI =	3.01E-01

Notes

* = Only the UTL test for aluminum and iron indicates a background exceedance.

TABLE 4
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - ADULT CONSTRUCTION WORKER EXPOSURE TO QUARRY 3 SOIL
REASONABLE MAXIMUM EXPOSURE
CRATER RESOURCES

Scenario Timeframe: Future
Receptor Population: Construction Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	Soil	Contact (Ing. & Der.) with Soil (Quarry 3)											
			Arsenic	4.14E-05	–	9.28E-07	4.24E-05	Arsenic	Skin/Vascular	6.45E+00	–	1.44E-01	6.59E+00
			Manganese	–	–	–	–	Manganese	CNS	9.23E-02	–	6.14E-04	9.29E-02
			Mercury	–	–	–	–	Mercury	CNS	1.44E+00	–	9.54E-03	1.45E+00
			2-Methylnaphthalene	–	–	–	–	2-Methylnaphthalene	Weight Loss	5.13E-01	–	4.26E-02	5.55E-01
			Benzo(a)pyrene	1.44E-04	–	–	1.44E-04	Benzo(a)pyrene	N/A	–	–	–	–
			Dibenz(a,h)anthracene	3.06E-05	–	–	3.06E-05	Dibenz(a,h)anthracene	N/A	–	–	–	–
			Naphthalene	–	–	–	–	Naphthalene	Weight Loss	3.96E+01	–	3.29E+00	4.29E+01
			(Total)	2.16E-04	–	9.28E-07	2.17E-04	(Total)		4.81E+01	–	3.48E+00	5.15E+01
	Air	Contact (Inh.) with Airborne Vapors from Soil (Quarry 3)											
			2-Methylnaphthalene	–	–	–	–	2-Methylnaphthalene	N/A	–	–	–	–
			Naphthalene	–	–	–	–	Naphthalene	Respiratory	–	1.62E+02	–	1.62E+02
			(Total)	–	–	–	–	(Total)		–	1.62E+02	–	1.62E+02
	Particulates	Contact (Inh.) with Particulates from Soil (Quarry 3)											
			Arsenic	–	5.98E-06	–	5.98E-06	Arsenic	N/A	–	–	–	–
			Manganese	–	–	–	–	Manganese	CNS	–	2.22E+00	–	2.22E+00
			Mercury	–	–	–	–	Mercury	CNS	–	2.40E-02	–	2.40E-02
			2-Methylnaphthalene	–	–	–	–	2-Methylnaphthalene	N/A	–	–	–	–
			Benzo(a)pyrene	–	8.74E-07	–	8.74E-07	Benzo(a)pyrene	N/A	–	–	–	–
			Dibenz(a,h)anthracene	–	–	–	–	Dibenz(a,h)anthracene	N/A	–	–	–	–
			Naphthalene	–	–	–	–	Naphthalene	Respiratory	–	1.26E+01	–	1.26E+01
			(Total)	–	6.85E-06	–	6.85E-06	(Total)		–	1.48E+01	–	1.48E+01
						Total Risk Across Soil	2.23E-04					Total Hazard Index Across Soil	2.29E+02
						Total Risk Across All Media and All Exposure Routes	2.23E-04					Total Hazard Index Across All Media and All Exposure Routes	2.29E+02

Total CNS HI = 3.78E+00
Total Respiratory HI = 1.75E+02
Total Skin HI = 6.59E+00
Total Vascular HI = 6.59E+00
Total Weight Loss HI = 4.34E+01

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T…
RY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - ADULT INDUSTRIAL WORKER EXPOSU… QUARRY 3 SURFACE SOIL, SEDIMENT, SURFACE WATER AND GROUNDWATER (CENTER OF P
REASONABLE MA…UM EXPOSURE
CRATER RESOURCES

Scenario Timeframe: Future
Receptor Population: Industrial Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk: Ingestion	Inhalation	Dermal	Exposure Routes Total	Chemical	Non-Carcinogenic Hazard Quotient: Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Contact (Ing. & Der.) with Groundwater (Center of Plume)	Arsenic	1.58E-04	–	3.28E-08	1.58E-04	Arsenic	Skin/Vascular	9.82E-01	–	2.05E-04	9.82E-01
			Barium	–	–	–	–	Barium	Kidney	9.97E-02	–	1.88E-05	9.97E-02
			Beryllium	–	–	–	–	Beryllium	GI Tract	1.21E-01	–	2.41E-03	1.24E-01
			Chromium	–	–	–	–	Chromium	Kidney	2.83E-01	–	5.76E-03	2.87E-01
			Cyanide	–	–	–	–	Cyanide	Thyroid/Nervous System/Weight Loss	5.48E-01	–	1.08E-04	5.49E-01
			Iron	–	–	–	–	Iron	Liver/Blood/GI Tract	2.13E+00	–	4.22E-04	2.13E+00
			Lead	–	–	–	–	Lead	N/A	–	–	–	–
			Manganese	–	–	–	–	Manganese	CNS	1.37E+01	–	2.72E-05	1.37E+01
			Selenium	–	–	–	–	Selenium	Blood/Skin/CNS	1.91E-01	–	4.21E-05	1.91E-01
			2,4-Dimethylphenol	–	–	–	–	2,4-Dimethylphenol	Blood/CNS	2.84E-01	–	2.83E-03	2.87E-01
			2-Methylphenol	–	–	–	–	2-Methylphenol	CNS/Weight Loss	1.23E+00	–	8.00E-03	1.24E+00
			4-Methylphenol	–	–	–	–	4-Methylphenol	CNS/Lung/Weight Loss	4.70E+01	–	5.01E-01	4.75E+01
			Dibenzofuran	–	–	–	–	Dibenzofuran	Kidney	3.91E-02	–	8.88E-03	4.80E-02
			Naphthalene	–	–	–	–	Naphthalene	Weight Loss	6.38E-01	–	4.30E-02	6.80E-01
			Phenol	–	–	–	–	Phenol	Fetal Weight	3.10E-01	–	1.07E-03	3.11E-01
			Acetone	–	–	–	–	Acetone	Liver/Kidney	4.11E-02	–	1.30E-05	4.11E-02
			Benzene	2.93E-05	–	2.97E-07	2.96E-05	Benzene	Blood/Immune	8.15E-01	–	9.57E-03	8.25E-01
			Chloroform	6.57E-08	–	4.38E-10	6.61E-08	Chloroform	Liver	3.01E-03	–	2.02E-05	3.03E-03
			(Total)	1.83E-04	–	3.31E-07	1.84E-04	(Total)		6.84E+01	–	5.87E-01	6.90E+01
Sediment	Sediment	Contact (Ing. & Der.) with Sediment (Quarry 3)	Benzo(a)anthracene	7.90E-06	–	–	7.90E-06	Benzo(a)anthracene	N/A	–	–	–	–
			Benzo(a)pyrene	8.90E-05	–	–	8.90E-05	Benzo(a)pyrene	N/A	–	–	–	–
			Benzo(b)fluoranthene	1.30E-05	–	–	1.30E-05	Benzo(b)fluoranthene	N/A	–	–	–	–
			Dibenzofuran	–	–	–	–	Dibenzofuran	Kidney	1.11E-02	–	1.99E-02	3.10E-02
			Naphthalene	–	–	–	–	Naphthalene	Weight Loss	2.93E-02	–	1.99E-02	4.89E-02
			(Total)	1.10E-04	–	–	1.10E-04	(Total)		4.04E-02	–	3.98E-02	7.99E-02
Surface Soil	Surface Soil	Contact (Ing. & Der.) with Surface Soil (Quarry 3)	Aluminum*	–	–	–	–	Aluminum*	CNS (Developmental)	1.31E-02	–	6.08E-04	1.37E-02
			Arsenic	7.82E-06	–	3.88E-06	8.28E-06	Arsenic	Skin/Vascular	4.92E-01	–	2.28E-02	5.15E-01
			Iron*	–	–	–	–	Iron*	Liver/Blood/GI Tract	8.58E-02	–	1.10E-03	8.69E-02
			Mercury	–	–	–	–	Mercury	CNS	1.10E-01	–	1.52E-03	1.12E-01
			Benzo(a)anthracene	5.10E-05	–	–	5.10E-05	Benzo(a)anthracene	N/A	–	–	–	–
			Benzo(a)pyrene	5.87E-04	–	–	5.87E-04	Benzo(a)pyrene	N/A	–	–	–	–
			Benzo(b)fluoranthene	8.04E-05	–	–	8.04E-05	Benzo(b)fluoranthene	N/A	–	–	–	–
			Dibenz(a,h)anthracene	1.28E-04	–	–	1.28E-04	Dibenz(a,h)anthracene	N/A	–	–	–	–
			Indeno(1,2,3-cd)pyrene	4.21E-05	–	–	4.21E-05	Indeno(1,2,3-cd)pyrene	N/A	–	–	–	–
			(Total)	9.67E-04	–	3.88E-06	9.71E-04	(Total)		7.01E-01	–	2.63E-02	7.28E-01
	Particulates	Contact (Inh.) with Particulates from Surface Soil (Quarry 3)	Aluminum*	–	–	–	–	Aluminum*	CNS	–	1.80E+00	–	1.80E+00
			Arsenic	–	1.10E-04	–	1.10E-04	Arsenic	N/A	–	–	–	–
			Iron*	–	–	–	–	Iron*	N/A	–	–	–	–
			Mercury	–	–	–	–	Mercury	CNS	–	1.77E-02	–	1.77E-02
			Benzo(a)anthracene	–	–	–	–	Benzo(a)anthracene	N/A	–	–	–	–
			Benzo(a)pyrene	–	3.43E-05	–	3.43E-05	Benzo(a)pyrene	N/A	–	–	–	–
			Benzo(b)fluoranthene	–	–	–	–	Benzo(b)fluoranthene	N/A	–	–	–	–
			Dibenz(a,h)anthracene	–	–	–	–	Dibenz(a,h)anthracene	N/A	–	–	–	–
			Indeno(1,2,3-cd)pyrene	–	–	–	–	Indeno(1,2,3-cd)pyrene	N/A	–	–	–	–
			(Total)	–	1.44E-04	–	1.44E-04	(Total)		–	1.81E+00	–	1.81E+00

Total Risk Across Groundwater	1.84E-04
Total Risk Across Sediment	1.10E-04
Total Risk Across Surface Soil	1.11E-03
Total Risk Across Surface Water	–
Total Risk Across All Media and All Exposure Routes	1.41E-03

Total Hazard Index Across Groundwater	6.90E+01
Total Hazard Index Across Sediment	7.99E-02
Total Hazard Index Across Surface Soil	2.54E+00
Total Hazard Index Across Surface Water	–
Total Hazard Index Across All Media and All Exposure Routes	7.16E+01

Total Blood HI =	3.52E+00
Total CNS HI =	6.46E+01
Total CNS (Developmental) HI =	1.37E-02
Total Fetal Weight HI =	3.11E-01
Total GI Tract HI =	2.34E+00
Total Immune HI =	8.25E-01
Total Kidney HI =	5.17E-01
Total Liver HI =	2.28E+00
Total Lung HI =	4.75E+01
Total Nervous System HI =	5.49E-01
Total Skin HI =	1.69E+00
Total Thyroid HI =	5.49E-01
Total Vascular HI =	1.50E+00
Total Weight Loss HI =	5.00E+01

Notes
* = Only the UTL test for aluminum and iron indicates a background exceedance.

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TABLE 4
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - CHILD RESIDENT EXPOSURE TO QUARRY 4 SURFACE SOIL AND GROUNDWATER (CENTER OF PLUME)
REASONABLE MAXIMUM EXPOSURE
CRATER RESOURCES

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Contact (Ing. & Der.) with Groundwater (Center of Plume)											
			Arsenic	2.88E-04	--	4.24E-07	2.89E-04	Arsenic	Skin/Vascular	7.49E+00	--	1.10E-02	7.49E+00
			Barium	--	--	--	--	Barium	Kidney	7.59E-01	--	1.06E-03	7.60E-01
			Beryllium	--	--	--	--	Beryllium	GI Tract	9.24E-01	--	1.29E-01	1.05E+00
			Chromium	--	--	--	--	Chromium	Kidney	2.22E+00	--	3.10E-01	2.53E+00
			Cyanide	--	--	--	--	Cyanide	Thyroid/Nervous System/Weight Los	4.17E+00	--	5.83E-03	4.18E+00
			Iron	--	--	--	--	Iron	Liver/Blood/GI Tract	1.62E+01	--	2.28E-02	1.62E+01
			Lead	--	--	--	--	Lead	N/A	--	--	--	--
			Manganese	--	--	--	--	Manganese	CNS	1.04E+02	--	1.46E-01	1.04E+02
			Selenium	--	--	--	--	Selenium	Blood/Skin/CNS	1.46E+00	--	2.28E-03	1.46E+00
			2,4-Dimethylphenol	--	--	--	--	2,4-Dimethylphenol	Blood/CNS	2.16E+00	--	1.52E-01	2.31E+00
			2-Methylphenol	--	--	--	--	2-Methylphenol	CNS/Weight Loss	9.39E+00	--	4.59E-01	9.85E+00
			4-Methylphenol	--	--	--	--	4-Methylphenol	CNS/Lung/Weight Loss	3.58E+02	--	2.69E+01	3.85E+02
			Dibenzofuran	--	--	--	--	Dibenzofuran	Kidney	2.98E-01	--	4.76E-01	7.74E-01
			Naphthalene	--	--	--	--	Naphthalene	Weight Loss	4.84E+00	--	2.35E+00	7.19E+00
			Phenol	--	--	--	--	Phenol	Fetal Weight	2.36E+00	--	5.76E-02	2.42E+00
			Acetone	--	--	--	--	Acetone	Liver/Kidney	3.13E-01	--	7.39E-04	3.14E-01
			Benzene	4.63E-05	--	3.83E-06	5.01E-05	Benzene	Blood/Immune	6.21E+00	--	5.14E-01	6.72E+00
			Chloroform	1.20E-07	--	5.66E-09	1.26E-07	Chloroform	Liver	2.30E-02	--	1.08E-03	2.40E-02
			(Total)	3.35E-04	--	4.26E-06	3.39E-04	(Total)		5.21E+02	--	3.15E+01	5.52E+02
Surface Soil	Surface Soil	Contact (Ing. & Der.) with Surface Soil (Quarry 4)											
			Aluminum*	--	--	--	--	Aluminum*	CNS (Developmental)	1.34E-01	--	2.33E-03	1.36E-01
			Chromium**	--	--	--	--	Chromium**	Kidney	1.27E+00	--	5.99E-01	1.87E+00
			Iron**	--	--	--	--	Iron**	Liver/Blood/GI Tract	4.35E+00	--	2.05E-02	4.37E+00
			Manganese**	--	--	--	--	Manganese**	CNS	2.98E+00	--	1.40E-02	3.00E+00
			(Total)	--	--	--	--	(Total)		8.74E+00	--	6.36E-01	9.38E+00
	Particulates	Contact (Inh.) with Particulates from Surface Soil (Quarry 4)											
			Aluminum*	--	--	--	--	Aluminum*	CNS	--	2.51E+00	--	2.51E+00
			Chromium**	--	2.52E-04	--	2.52E-04	Chromium**	Lung	--	2.51E+00	--	2.51E+00
			Iron**	--	--	--	--	Iron**	N/A	--	--	--	--
			Manganese**	--	--	--	--	Manganese**	CNS	--	9.39E+01	--	9.39E+01
			(Total)	--	2.52E-04	--	2.52E-04	(Total)		--	9.89E+01	--	9.89E+01

Total Risk Across Groundwater	3.39E-04
Total Risk Across Surface Soil	2.52E-04
Total Risk Across All Media and All Exposure Routes	5.91E-04

Total Hazard Index Across Groundwater	5.52E+02
Total Hazard Index Across Surface Soil	1.08E+02
Total Hazard Index Across All Media and All Exposure Routes	6.61E+02

Total Blood HI =	3.11E+01
Total CNS HI =	6.02E+02
Total CNS (Developmental) HI =	1.36E-01
Total Fetal Weight HI =	2.42E+00
Total GI Tract HI =	2.16E+01
Total Immune HI =	6.72E+00
Total Kidney HI =	6.25E+00
Total Liver HI =	2.09E+01
Total Lung HI =	3.87E+02
Total Nervous System HI =	4.18E+00
Total Skin HI =	8.95E+00
Total Thyroid HI =	4.18E+00
Total Vascular HI =	[illegible]E+00
Total Weight Loss HI =	[illegible]E+02

Notes
* = Only the UTL test for aluminum indicates a background exceedance.
** = Chromium, iron, and manganese appear to be below background, however, the sample size is small and the background comparison test has very little power.

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SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - ADULT RESIDENT URE TO QUARRY 4 SURFACE SOIL AND GROUNDWATER (CENTER OF PLUME)
REASONABLE MA...UM EXPOSURE
CRATER RESOURCES

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Contact (Ing. & Der.) with Groundwater (Center of Plume)	Arsenic	4.24E-04	–	1.81E-06	4.24E-04	Arsenic	Skin/Vascular	2.70E+00	–	8.98E-03	2.70E+00
			Barium	–	–	–	–	Barium	Kidney	2.78E-01	–	6.33E-04	2.80E-01
			Beryllium	–	–	–	–	Beryllium	GI Tract	3.40E-01	–	7.71E-02	4.17E-01
			Chromium	–	–	–	–	Chromium	Kidney	8.10E-01	–	1.88E-01	1.00E+00
			Cyanide	–	–	–	–	Cyanide	Thyroid/Nervous System/Weight Loss	1.53E+00	–	3.40E-03	1.54E+00
			Iron	–	–	–	–	Iron	Liver/Blood/GI Tract	5.96E+00	–	1.30E-02	5.97E+00
			Lead	–	–	–	–	Lead	NA	–	–	–	–
			Manganese	–	–	–	–	Manganese	CNS	3.04E+01	–	8.78E-02	3.04E+01
			Selenium	–	–	–	–	Selenium	Blood/Skin/CNS	5.36E-01	–	1.30E-03	5.37E-01
			2,4-Dimethylphenol	–	–	–	–	2,4-Dimethylphenol	Blood/CNS	7.98E-01	–	8.83E-02	8.86E-01
			2-Methylphenol	–	–	–	–	2-Methylphenol	CNS/Weight Loss	3.46E+00	–	2.74E-01	3.73E+00
			4-Methylphenol	–	–	–	–	4-Methylphenol	CNS/Lung/Weight Loss	1.32E+02	–	1.08E+01	1.40E+02
			Dibenzofuran	–	–	–	–	Dibenzofuran	Kidney	1.10E-01	–	2.84E-01	3.94E-01
			Naphthalene	–	–	–	–	Naphthalene	Weight Loss	1.70E+00	–	9.82E-01	2.77E+00
			Phenol	–	–	–	–	Phenol	Fetal Weight	8.48E-01	–	3.44E-02	8.82E-01
			Acetone	–	–	–	–	Acetone	Liver/Kidney	1.10E-01	–	4.18E-04	1.10E-01
			Benzene	6.81E-05	–	4.78E-06	7.28E-05	Benzene	Blood/Immune	2.30E+00	–	1.41E-01	2.44E+00
			Chloroform	1.70E-07	–	8.07E-09	1.85E-07	Chloroform	Liver	8.44E-03	–	3.80E-04	8.82E-03
			(Total)	4.92E-04	–	6.61E-06	4.98E-04	(Total)		1.91E+02	–	1.82E+01	2.10E+02
	Air	Contact (Inh.) with Airborne Vapors from Groundwater (Center of Plume)	Arsenic	–	NA	–	–	Arsenic	NA	–	–	–	–
			Barium	–	–	–	–	Barium	Fetotoxicity	–	NA	–	–
			Beryllium	–	NA	–	–	Beryllium	Respiratory/Immune	–	NA	–	–
			Chromium	–	NA	–	–	Chromium	Lung	–	NA	–	–
			Cyanide	–	–	–	–	Cyanide	NA	–	–	–	–
			Iron	–	–	–	–	Iron	NA	–	–	–	–
			Lead	–	–	–	–	Lead	NA	–	–	–	–
			Manganese	–	–	–	–	Manganese	CNS	–	NA	–	–
			Selenium	–	–	–	–	Selenium	NA	–	–	–	–
			2,4-Dimethylphenol	–	–	–	–	2,4-Dimethylphenol	NA	–	–	–	–
			2-Methylphenol	–	–	–	–	2-Methylphenol	NA	–	–	–	–
			4-Methylphenol	–	–	–	–	4-Methylphenol	NA	–	–	–	–
			Dibenzofuran	–	–	–	–	Dibenzofuran	NA	–	–	–	–
			Naphthalene	–	–	–	–	Naphthalene	Respiratory	–	4.48E+01	–	4.48E+01
			Phenol	–	–	–	–	Phenol	NA	–	–	–	–
			Acetone	–	–	–	–	Acetone	NA	–	–	–	–
			Benzene	–	1.28E-04	–	1.28E-04	Benzene	Blood	–	7.49E+00	–	7.49E+00
			Chloroform	–	3.65E-06	–	3.65E-06	Chloroform	Respiratory	–	1.53E+00	–	1.53E+00
			(Total)	–	1.28E-04	–	1.28E-04	(Total)		–	5.38E+01	–	5.38E+01
Surface Soil	Surface Soil	Contact (Ing. & Der.) with Surface Soil (Quarry 4)	Aluminum*	–	–	–	–	Aluminum*	CNS (Developmental)	1.58E-02	–	4.10E-04	1.63E-02
			Chromium**	–	–	–	–	Chromium**	Kidney	1.51E-01	–	1.07E-01	2.58E-01
			Iron**	–	–	–	–	Iron**	Liver/Blood/GI Tract	5.10E-01	–	3.00E-03	5.20E-01
			Manganese**	–	–	–	–	Manganese**	CNS	3.54E-01	–	2.51E-03	3.56E-01
			(Total)	–	–	–	–	(Total)		1.04E+00	–	1.14E-01	1.15E+00
	Particulates	Contact (Inh.) with Particulates from Surface Soil (Quarry 4)	Aluminum*	–	–	–	–	Aluminum*	CNS	–	6.27E-01	–	6.27E-01
			Chromium**	–	3.32E-04	–	3.32E-04	Chromium**	Lung	–	6.29E-01	–	6.29E-01
			Iron**	–	–	–	–	Iron**	NA	–	–	–	–
			Manganese**	–	–	–	–	Manganese**	CNS	–	3.08E+01	–	3.08E+01
			(Total)	–	3.32E-04	–	3.32E-04	(Total)		–	3.20E+01	–	3.20E+01

Total Risk Across Groundwater	6.27E-04
Total Risk Across Surface Soil	3.32E-04
Total Risk Across All Media and All Exposure Routes	9.59E-04

Total Hazard Index Across Groundwater	2.64E+02
Total Hazard Index Across Surface Soil	3.37E+01
Total Hazard Index Across All Media and All Exposure Routes	2.97E+02

Total Blood HI =	1.78E+01
Total CNS HI =	2.23E+02
Total CNS (Developmental) HI =	1.63E-02
Total Fetal Weight HI =	8.82E-01
Total Fetotoxicity HI =	–
Total GI Tract HI =	6.80E+00
Total Immune HI =	2.44E+00
Total Kidney HI =	2.05E+00
Total Liver HI =	6.61E+00
Total Lung HI =	1.40E+02
Total Nervous System HI =	1.54E+00
Total Respiratory HI =	4.64E+01
Total Skin HI =	3.29E+00
Total Thyroid HI =	1.54E+00
Total Vascular HI =	2.70E+00
Total Weight Loss HI =	1.58E+02

Notes:
* = Only the UTL test for aluminum indicates a background exceedance.
** = Chromium, Iron, and manganese appear to be below background, however, the sample size is small and the background comparison test has very little power.

TABLE 4
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - LIFETIME RESIDENT EXPOSURE TO QUARRY 4 SURFACE SOIL AND GROUNDWATER (CENTER OF PLUME)
REASONABLE MAXIMUM EXPOSURE
CRATER RESOURCES

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Contact (Ing. & Der.) with Groundwater (Center of Plume)	Arsenic	7.12E-04	--	1.44E-06	7.14E-04	Arsenic	N/A	N/A	--	N/A	--
			Barium	--	--	--	--	Barium	N/A	N/A	--	N/A	--
			Beryllium	--	--	--	--	Beryllium	N/A	N/A	--	N/A	--
			Chromium	--	--	--	--	Chromium	N/A	N/A	--	N/A	--
			Cyanide	--	--	--	--	Cyanide	N/A	N/A	--	N/A	--
			Iron	--	--	--	--	Iron	N/A	N/A	--	N/A	--
			Lead	--	--	--	--	Lead	N/A	N/A	--	N/A	--
			Manganese	--	--	--	--	Manganese	N/A	N/A	--	N/A	--
			Selenium	--	--	--	--	Selenium	N/A	N/A	--	N/A	--
			2,4-Dimethylphenol	--	--	--	--	2,4-Dimethylphenol	N/A	N/A	--	N/A	--
			2-Methylphenol	--	--	--	--	2-Methylphenol	N/A	N/A	--	N/A	--
			4-Methylphenol	--	--	--	--	4-Methylphenol	N/A	N/A	--	N/A	--
			Dibenzofuran	--	--	--	--	Dibenzofuran	N/A	N/A	--	N/A	--
			Naphthalene	--	--	--	--	Naphthalene	N/A	N/A	--	N/A	--
			Phenol	--	--	--	--	Phenol	N/A	N/A	--	N/A	--
			Acetone	--	--	--	--	Acetone	N/A	N/A	--	N/A	--
			Benzene	1.14E-04	--	8.62E-06	1.23E-04	Benzene	N/A	N/A	--	N/A	--
			Chloroform	2.96E-07	--	1.37E-08	3.10E-07	Chloroform	N/A	N/A	--	N/A	--
			(Total)	8.27E-04	--	1.01E-05	8.37E-04	(Total)		--	--	--	--
	Air	Contact (Inh.) with Airborne Vapors from Groundwater (Center of Plume)	Arsenic	--	--	--	--	Arsenic	N/A	--	N/A	--	--
			Barium	--	--	--	--	Barium	N/A	--	N/A	--	--
			Beryllium	--	--	--	--	Beryllium	N/A	--	N/A	--	--
			Chromium	--	--	--	--	Chromium	N/A	--	N/A	--	--
			Cyanide	--	--	--	--	Cyanide	N/A	--	N/A	--	--
			Iron	--	--	--	--	Iron	N/A	--	N/A	--	--
			Lead	--	--	--	--	Lead	N/A	--	N/A	--	--
			Manganese	--	--	--	--	Manganese	N/A	--	N/A	--	--
			Selenium	--	--	--	--	Selenium	N/A	--	N/A	--	--
			2,4-Dimethylphenol	--	--	--	--	2,4-Dimethylphenol	N/A	--	N/A	--	--
			2-Methylphenol	--	--	--	--	2-Methylphenol	N/A	--	N/A	--	--
			4-Methylphenol	--	--	--	--	4-Methylphenol	N/A	--	N/A	--	--
			Dibenzofuran	--	--	--	--	Dibenzofuran	N/A	--	N/A	--	--
			Naphthalene	--	--	--	--	Naphthalene	N/A	--	N/A	--	--
			Phenol	--	--	--	--	Phenol	N/A	--	N/A	--	--
			Acetone	--	--	--	--	Acetone	N/A	--	N/A	--	--
			Benzene	--	1.28E-04	--	1.28E-04	Benzene	N/A	--	N/A	--	--
			Chloroform	--	3.85E-06	--	3.85E-06	Chloroform	N/A	--	N/A	--	--
			(Total)	--	1.29E-04	--	1.29E-04	(Total)		--	--	--	--
Surface Soil	Surface Soil	Contact (Ing. & Der.) with Surface Soil (Quarry 4)	Aluminum*	--	--	--	--	Aluminum*	N/A	N/A	--	N/A	--
			Chromium**	--	--	--	--	Chromium**	N/A	N/A	--	N/A	--
			Iron**	--	--	--	--	Iron**	N/A	N/A	--	N/A	--
			Manganese**	--	--	--	--	Manganese**	N/A	N/A	--	N/A	--
			(Total)	--	--	--	--	(Total)		--	--	--	--
	Particulates	Contact (Inh.) with Particulates from Surface Soil (Quarry 4)	Aluminum*	--	--	--	--	Aluminum*	N/A	--	N/A	--	--
			Chromium**	--	5.84E-04	--	5.84E-04	Chromium**	N/A	--	N/A	--	--
			Iron**	--	--	--	--	Iron**	N/A	--	N/A	--	--
			Manganese**	--	--	--	--	Manganese**	N/A	--	N/A	--	--
			(Total)	--	5.84E-04	--	5.84E-04	(Total)		--	--	--	--
					Total Risk Across Groundwater		9.66E-04			Total Hazard Index Across Groundwater			--
					Total Risk Across Surface Soil		5.84E-04			Total Hazard Index Across Surface Soil			--
					Total Risk Across All Media and All Exposure Routes		1.55E-03			Total Hazard Index Across All Media and All Exposure Routes			--

Notes
* = Only the UTL test for aluminum indicates a background exceedance.
** = Chromium, iron, and manganese appear to be below background, however, the sample size is small and the background comparison test has very little power.

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TABLE 4
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - ADOLESCENT (TEENS) TRESPASSER/VISITOR EXPOSURE TO QUARRY 4 SURFACE SOIL
REASONABLE MAXIMUM EXPOSURE
CRATER RESOURCES

Scenario Timeframe: Current
Receptor Population: Trespasser/Visitor
Receptor Age: Adolescent (Teens)

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil	Surface Soil	Contact (Ing. & Der.) with Surface Soil (Quarry 4)	Aluminum*	–	–	–	–	Aluminum*	CNS (Developmental)	5.39E-03	–	2.89E-04	5.68E-03
			Chromium**	–	–	–	–	Chromium**	Kidney	5.12E-02	–	7.43E-02	1.26E-01
			Iron**	–	–	–	–	Iron**	Liver/Blood/GI Tract	1.75E-01	–	2.54E-03	1.77E-01
			Manganese**	–	–	–	–	Manganese**	CNS	1.20E-01	–	1.74E-03	1.22E-01
			(Total)	–	–	–	–	(Total)		3.51E-01	–	7.89E-02	4.30E-01
	Particulates	Contact (Inh.) with Particulates from Surface Soil (Quarry 4)	Aluminum*	–	–	–	–	Aluminum*	CNS	–	6.73E-02	–	6.73E-02
			Chromium**	–	1.13E-05	–	1.13E-05	Chromium**	Lung	–	6.72E-02	–	6.72E-02
			Iron**	–	–	–	–	Iron**	N/A	–	–	–	–
			Manganese**	–	–	–	–	Manganese**	CNS	–	2.52E+00	–	2.52E+00
			(Total)	–	1.13E-05	–	1.13E-05	(Total)		–	2.65E+00	–	2.65E+00
						Total Risk Across Surface Soil	1.13E-05					Total Hazard Index Across Surface Soil	3.08E+00
						Total Risk Across All Media and All Exposure Routes	1.13E-05					Total Hazard Index Across All Media and All Exposure Routes	3.08E+00

Total Blood HI =	1.77E-01
Total CNS HI =	2.71E+00
Total CNS (Developmental) HI =	5.68E-03
Total GI Tract HI =	1.77E-01
Total Kidney HI =	1.26E-01
Total Liver HI =	1.77E-01
Total Lung HI =	6.72E-02

Notes
* = Only the UTL test for aluminum indicates a background exceedance.
** = Chromium, iron, and manganese appear to be below background, however, the sample size is small and the background comparison test has very little power.

TABLE 4
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - ADULT CONSTRUCTION WORKER EXPOSURE TO QUARRY 4 SOIL
REASONABLE MAXIMUM EXPOSURE
CRATER RESOURCES

Scenario Timeframe: Future
Receptor Population: Construction Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	Soil	Contact (Ing. & Der.) with Soil (Quarry 4)											
			Aluminum*	--	--	--	--	Aluminum*	CNS (Developmental)	6.62E-02	--	1.63E-03	6.79E-02
			Manganese*	--	--	--	--	Manganese*	CNS	7.57E-01	--	5.03E-03	7.62E-01
			Vanadium	--	--	--	--	Vanadium	NOAEL	8.96E-01	--	2.98E-01	1.19E+00
			(Total)	--	--	--	--	(Total)		1.72E+00	--	3.04E-01	2.02E+00
	Particulates	Contact (inh.) with Particulates from Soil (Quarry 4)											
			Aluminum*	--	--	--	--	Aluminum*	CNS	--	9.49E-01	--	9.49E-01
			Manganese*	--	--	--	--	Manganese*	CNS	--	1.82E+01	--	1.82E+01
			Vanadium	--	--	--	--	Vanadium	N/A	--	--	--	--
			(Total)	--	--	--	--	(Total)		--	1.91E+01	--	1.91E+01
						Total Risk Across Soil	--					Total Hazard Index Across Soil	2.12E+01
						Total Risk Across All Media and All Exposure Routes	--					Total Hazard Index Across All Media and All Exposure Routes	2.12E+01

Total CNS HI = 2.00E+01
Total CNS (Developmental) HI = 6.79E-02
Total NOAEL HI = 1.19E+00

Notes
* = Only the UTL test for aluminum and manganese indicates a background exceedance.

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S[illegible]MMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - ADULT INDUSTRIAL WOR[illegible] EXPOSURE TO QUARRY 4 SURFACE SOIL AND GROUNDWATER (CENTER OF PLUME)
REASONABLE MAXIMUM EXPOSURE
CRATER RESOURCES

Scenario Timeframe: Current
Receptor Population: Industrial Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Contact (Ing. & Der.) with Groundwater (Center of Plume)											
			Arsenic	1.58E-04	–	3.29E-08	1.58E-04	Arsenic	Skin/Vascular	9.82E-01	–	2.05E-04	9.82E-01
			Barium	–	–	–	–	Barium	Kidney	9.97E-02	–	1.98E-05	9.97E-02
			Beryllium	–	–	–	–	Beryllium	GI Tract	1.21E-01	–	2.41E-03	1.24E-01
			Chromium	–	–	–	–	Chromium	Kidney	2.92E-01	–	5.78E-03	2.97E-01
			Cyanide	–	–	–	–	Cyanide	Thyroid/Nervous System/Weight Los	5.48E-01	–	1.09E-04	5.48E-01
			Iron	–	–	–	–	Iron	Liver/Blood/GI Tract	2.13E+00	–	4.22E-04	2.13E+00
			Lead	–	–	–	–	Lead	N/A	–	–	–	–
			Manganese	–	–	–	–	Manganese	CNS	1.37E+01	–	2.72E-03	1.37E+01
			Selenium	–	–	–	–	Selenium	Blood/Skin/CNS	1.91E-01	–	4.21E-05	1.91E-01
			2,4-Dimethylphenol	–	–	–	–	2,4-Dimethylphenol	Blood/CNS	2.84E-01	–	2.83E-03	2.87E-01
			2-Methylphenol	–	–	–	–	2-Methylphenol	CNS/Weight Loss	1.23E+00	–	8.55E-03	1.24E+00
			4-Methylphenol	–	–	–	–	4-Methylphenol	CNS/Lung/Weight Loss	4.70E+01	–	5.01E-01	4.75E+01
			Dibenzofuran	–	–	–	–	Dibenzofuran	Kidney	3.91E-02	–	8.86E-03	4.80E-02
			Naphthalene	–	–	–	–	Naphthalene	Weight Loss	6.36E-01	–	4.38E-02	6.80E-01
			Phenol	–	–	–	–	Phenol	Fetal Weight	3.10E-01	–	1.07E-03	3.11E-01
			Acetone	–	–	–	–	Acetone	Liver/Kidney	4.11E-02	–	1.38E-05	4.11E-02
			Benzene	2.53E-05	–	2.97E-07	2.56E-05	Benzene	Blood/Immune	8.15E-01	–	9.57E-03	8.25E-01
			Chloroform	6.57E-08	–	4.39E-10	6.61E-08	Chloroform	Liver	3.01E-03	–	2.02E-05	3.03E-03
			(Total)	1.83E-04	–	3.31E-07	1.84E-04	(Total)		6.84E+01	–	5.87E-01	6.90E+01
Surface Soil	Surface Soil	Contact (Ing. & Der.) with Surface Soil (Quarry 4)											
			Aluminum*	–	–	–	–	Aluminum*	CNS (Developmental)	5.68E-03	–	2.90E-04	5.97E-03
			Chromium**	–	–	–	–	Chromium**	Kidney	5.40E-02	–	7.45E-02	1.28E-01
			Iron**	–	–	–	–	Iron**	Liver/Blood/GI Tract	1.84E-01	–	2.54E-03	1.87E-01
			Manganese**	–	–	–	–	Manganese**	CNS	1.26E-01	–	1.74E-03	1.28E-01
			(Total)	–	–	–	–	(Total)		3.70E-01	–	7.91E-02	4.49E-01
	Particulates	Contact (Inh.) with Particulates from Surface Soil (Quarry 4)											
			Aluminum*	–	–	–	–	Aluminum*	CNS	–	7.80E-01	–	7.80E-01
			Chromium**	–	3.26E-04	–	3.26E-04	Chromium**	Lung	–	7.79E-01	–	7.79E-01
			Iron**	–	–	–	–	Iron**	N/A	–	–	–	–
			Manganese**	–	–	–	–	Manganese**	CNS	–	2.92E+01	–	2.92E+01
			(Total)	–	3.26E-04	–	3.26E-04	(Total)		–	3.07E+01	–	3.07E+01

Total Risk Across Groundwater	1.84E-04
Total Risk Across Surface Soil	3.26E-04
Total Risk Across All Media and All Exposure Routes	5.10E-04

Total Hazard Index Across Groundwater	6.90E+01
Total Hazard Index Across Surface Soil	3.12E+01
Total Hazard Index Across All Media and All Exposure Routes	1.00E+02

Total Blood HI =	3.62E+00
Total CNS HI =	9.30E+01
Total CNS (Developmental) HI =	5.97E-03
Total Fetal Weight HI =	3.11E-01
Total GI Tract HI =	2.44E+00
Total Immune HI =	8.25E-01
Total Kidney HI =	6.15E-01
Total Liver HI =	2.36E+00
Total Lung HI =	4.82E+01
Total Nervous System HI =	5.48E-01
Total Skin HI =	1.17E+00
Total Thyroid HI =	5.48E-01
Total Vascular HI =	9.82E-01
Total Weight Loss HI =	4.99E+01

Notes
* = Only the UTL test for aluminum indicates a background exceedance.
** = Chromium, iron, and manganese appear to be below background, however, the sample size is small and the background comparison test has very little power.

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TABLE 4
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - ADULT CONSTRUCTION WORKER EXPOSURE TO QUARRY 6 SOIL
REASONABLE MAXIMUM EXPOSURE
CRATER RESOURCES

Scenario Timeframe: Future
Receptor Population: Construction Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	Soil	Contact (Ing. & Der.) with Soil (Quarry 6)											
			Aluminum*	–	–	–	–	Aluminum*	CNS (Developmental)	2.39E-02	–	5.86E-04	2.45E-02
			Iron*	–	–	–	–	Iron*	Liver/Blood/GI Tract	3.04E-01	–	2.02E-03	3.06E-01
			Manganese*	–	–	–	–	Manganese*	CNS	2.26E-02	–	1.50E-04	2.27E-02
			2-Methylnaphthalene	–	–	–	–	2-Methylnaphthalene	Weight Loss	7.33E-01	–	6.08E-02	7.94E-01
			4-Methylphenol	–	–	–	–	4-Methylphenol	CNS/Lung/Weight Loss	3.63E-01	–	3.72E-02	4.01E-01
			Benz(a)anthracene	2.89E-04	–	–	2.89E-04	Benz(a)anthracene	N/A	–	–	–	–
			Benzo(a)pyrene	2.46E-03	–	–	2.46E-03	Benzo(a)pyrene	N/A	–	–	–	–
			Benzo(b)fluoranthene	1.74E-04	–	–	1.74E-04	Benzo(b)fluoranthene	N/A	–	–	–	–
			Dibenz(a,h)anthracene	4.86E-04	–	–	4.86E-04	Dibenz(a,h)anthracene	N/A	–	–	–	–
			Dibenzofuran	–	–	–	–	Dibenzofuran	Kidney	5.28E+00	–	5.01E-01	5.78E+00
			Fluoranthene	–	–	–	–	Fluoranthene	Kidney/Liver/Blood	1.61E+00	–	1.53E-01	1.76E+00
			Fluorene	–	–	–	–	Fluorene	Blood	7.03E-01	–	6.68E-02	7.70E-01
			Indeno(1,2,3-cd)pyrene	1.41E-04	–	–	1.41E-04	Indeno(1,2,3-cd)pyrene	N/A	–	–	–	–
			Naphthalene	–	–	–	–	Naphthalene	Weight Loss	4.25E+00	–	3.53E-01	4.60E+00
			Pyrene	–	–	–	–	Pyrene	Kidney	2.25E+00	–	1.87E-01	2.43E+00
			(Total)	3.55E-03	–	–	3.55E-03	(Total)		1.55E+01	–	1.36E+00	1.69E+01
	Air	Contact (Inh.) with Airborne Vapors from Soil (Quarry 6)											
			2-Methylnaphthalene	–	–	–	–	2-Methylnaphthalene	N/A	–	–	–	–
			Naphthalene	–	–	–	–	Naphthalene	Respiratory	–	1.05E+01	–	1.05E+01
			(Total)	–	–	–	–	(Total)		–	1.05E+01	–	1.05E+01
	Particulates	Contact (Inh.) with Particulates from Soil (Quarry 6)											
			Aluminum*	–	–	–	–	Aluminum*	CNS	–	3.43E-01	–	3.43E-01
			Iron*	–	–	–	–	Iron*	N/A	–	–	–	–
			Manganese*	–	–	–	–	Manganese*	CNS	–	5.43E-01	–	5.43E-01
			2-Methylnaphthalene	–	–	–	–	2-Methylnaphthalene	N/A	–	–	–	–
			4-Methylphenol	–	–	–	–	4-Methylphenol	N/A	–	–	–	–
			Benz(a)anthracene	–	–	–	–	Benz(a)anthracene	N/A	–	–	–	–
			Benzo(a)pyrene	–	1.51E-05	–	1.51E-05	Benzo(a)pyrene	N/A	–	–	–	–
			Benzo(b)fluoranthene	–	–	–	–	Benzo(b)fluoranthene	N/A	–	–	–	–
			Dibenz(a,h)anthracene	–	–	–	–	Dibenz(a,h)anthracene	N/A	–	–	–	–
			Dibenzofuran	–	–	–	–	Dibenzofuran	N/A	–	–	–	–
			Fluoranthene	–	–	–	–	Fluoranthene	N/A	–	–	–	–
			Fluorene	–	–	–	–	Fluorene	N/A	–	–	–	–
			Indeno(1,2,3-cd)pyrene	–	–	–	–	Indeno(1,2,3-cd)pyrene	N/A	–	–	–	–
			Naphthalene	–	–	–	–	Naphthalene	Respiratory	–	1.35E+00	–	1.35E+00
			Pyrene	–	–	–	–	Pyrene	N/A	–	–	–	–
			(Total)	–	1.51E-05	–	1.51E-05	(Total)		–	2.24E+00	–	2.24E+00
						Total Risk Across Soil	3.56E-03					Total Hazard Index Across Soil	2.97E+01
						Total Risk Across All Media and All Exposure Routes	3.56E-03					Total Hazard Index Across All Media and All Exposure Routes	2.97E+01

Total Blood HI =	2.84E+00
Total CNS HI =	1.33E+00
Total CNS (Developmental) HI =	2.45E-02
Total GI Tract HI =	3.06E-01
Total Kidney HI =	9.97E+00
Total Liver HI =	2.07E+00
Total Lung HI =	4.01E-01
Total Respiratory HI =	1.19E+01
Total Weight Loss HI =	5.80E+00

Notes
* = Aluminum, iron, and manganese appear to be below background, however, the sample size is small and the background comparison test has very little power.

** = [illegible]

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TABLE 4
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - CHILD RESIDENT EXPOSURE TO SS-1 + SS-2 SURFACE SOIL AND GROUNDWATER (CENTER OF PLUME)
REASONABLE MAXIMUM EXPOSURE
CRATER RESOURCES

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Contact (Ing. & Der.) with Groundwater (Center of Plume)											
			Arsenic	2.86E-04	--	4.24E-07	2.87E-04	Arsenic	Skin/Vascular	7.48E+00	--	1.10E-02	7.49E+00
			Barium	--	--	--	--	Barium	Kidney	7.59E-01	--	1.08E-03	7.60E-01
			Beryllium	--	--	--	--	Beryllium	GI Tract	9.24E-01	--	1.29E-01	1.05E+00
			Chromium	--	--	--	--	Chromium	Kidney	2.22E+00	--	3.10E-01	2.53E+00
			Cyanide	--	--	--	--	Cyanide	Thyroid/Nervous System/Weight Loss	4.17E+00	--	5.83E-03	4.18E+00
			Iron	--	--	--	--	Iron	Liver/Blood/GI Tract	1.62E+01	--	2.28E-02	1.62E+01
			Lead	--	--	--	--	Lead	N/A	--	--	--	--
			Manganese	--	--	--	--	Manganese	CNS	1.04E+02	--	1.40E-01	1.04E+02
			Selenium	--	--	--	--	Selenium	Blood/Skin/CNS	1.40E+00	--	2.28E-03	1.40E+00
			2,4-Dimethylphenol	--	--	--	--	2,4-Dimethylphenol	Blood/CNS	2.16E+00	--	1.52E-01	2.31E+00
			2-Methylphenol	--	--	--	--	2-Methylphenol	CNS/Weight Loss	9.36E+00	--	4.90E-01	9.85E+00
			4-Methylphenol	--	--	--	--	4-Methylphenol	CNS/Lung/Weight Loss	3.58E+02	--	2.68E+01	3.85E+02
			Dibenzofuran	--	--	--	--	Dibenzofuran	Kidney	2.98E-01	--	4.76E-01	7.74E-01
			Naphthalene	--	--	--	--	Naphthalene	Weight Loss	4.84E+00	--	2.35E+00	7.19E+00
			Phenol	--	--	--	--	Phenol	Fetal Weight	2.36E+00	--	5.70E-02	2.42E+00
			Acetone	--	--	--	--	Acetone	Liver/Kidney	3.13E-01	--	7.30E-04	3.14E-01
			Benzene	4.83E-05	--	3.83E-06	5.21E-05	Benzene	Blood/Immune	6.21E+00	--	5.14E-01	6.72E+00
			Chloroform	1.20E-07	--	5.88E-09	1.26E-07	Chloroform	Liver	2.30E-02	--	1.08E-03	2.40E-02
			(Total)	3.35E-04	--	4.26E-06	3.39E-04	(Total)		5.21E+02	--	3.15E+01	5.52E+02
Surface Soil	Surface Soil	Contact (Ing. & Der.) with Surface Soil (SS-1 + SS-2)											
			Aluminum*	--	--	--	--	Aluminum*	CNS (Developmental)	1.12E-01	--	1.95E-03	1.14E-01
			Iron*	--	--	--	--	Iron*	Liver/Blood/GI Tract	1.99E+00	--	9.30E-03	2.00E+00
			Manganese*	--	--	--	--	Manganese*	CNS	9.34E-01	--	4.30E-03	9.38E-01
			(Total)	--	--	--	--	(Total)		3.04E+00	--	1.57E-02	3.05E+00
	Particulates	Contact (Inh.) with Particulates from Surface Soil (SS-1 + SS-2)											
			Aluminum*	--	--	--	--	Aluminum*	CNS	--	2.10E+00	--	2.10E+00
			Iron*	--	--	--	--	Iron*	N/A	--	--	--	--
			Manganese*	--	--	--	--	Manganese*	CNS	--	2.94E+01	--	2.94E+01
			(Total)	--	--	--	--	(Total)		--	3.15E+01	--	3.15E+01

Total Risk Across Groundwater	3.39E-04
Total Risk Across Surface Soil	--
Total Risk Across All Media and All Exposure Routes	3.39E-04

Total Hazard Index Across Groundwater	5.52E+02
Total Hazard Index Across Surface Soil	3.45E+01
Total Hazard Index Across All Media and All Exposure Routes	5.67E+02

Total Blood HI =	2.87E+01
Total CNS HI =	5.35E+02
Total CNS (Developmental) HI =	1.14E-01
Total Fetal Weight HI =	2.42E+00
Total GI Tract HI =	1.93E+01
Total Immune HI =	6.72E+00
Total Kidney HI =	4.38E+00
Total Liver HI =	1.86E+01
Total Lung HI =	3.85E+02
Total Nervous System HI =	4.18E+00
Total Skin HI =	8.95E+00
Total Thyroid HI =	4.18E+00
Total Vascular HI =	7.49E+00
Total Weight Loss HI =	4.06E+02

Notes
* = Aluminum, iron, and manganese appear to be below background, however, the sample size is small and the background comparison test has very little power.

TABLE 4
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - ADULT RESIDENT EXPOSURE TO SS-01 + SS-02 SURFACE SOIL AND GROUNDWATER (CENTER OF PLUME)
REASONABLE MAXIMUM EXPOSURE
CRATER RESOURCES

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Contact (Ing. & Der.) with Groundwater (Center of Plume)	Arsenic	4.24E-04	–	1.01E-08	4.25E-04	Arsenic	Skin/Vascular	2.75E+00	–	6.58E-03	2.76E+00
			Barium	–	–	–	–	Barium	Kidney	2.79E-01	–	6.33E-04	2.80E-01
			Beryllium	–	–	–	–	Beryllium	GI Tract	3.40E-01	–	7.71E-02	4.17E-01
			Chromium	–	–	–	–	Chromium	Kidney	8.14E-01	–	1.86E-01	1.00E+00
			Cyanide	–	–	–	–	Cyanide	Thyroid/Nervous System/Weight Loss	1.53E+00	–	3.40E-03	1.54E+00
			Iron	–	–	–	–	Iron	Liver/Blood/GI Tract	5.86E+00	–	1.28E-02	5.87E+00
			Lead	–	–	–	–	Lead	N/A	–	–	–	–
			Manganese	–	–	–	–	Manganese	CNS	3.84E+01	–	8.70E-02	3.84E+01
			Selenium	–	–	–	–	Selenium	Blood/Skin/CNS	5.36E-01	–	1.35E-03	5.37E-01
			2,4-Dimethylphenol	–	–	–	–	2,4-Dimethylphenol	Blood/CNS	7.85E-01	–	8.03E-02	8.65E-01
			2-Methylphenol	–	–	–	–	2-Methylphenol	CNS/Weight Loss	3.46E+00	–	2.74E-01	3.73E+00
			4-Methylphenol	–	–	–	–	4-Methylphenol	CNS/Lung/Weight Loss	1.32E+02	–	1.60E+01	1.48E+02
			Dibenzofuran	–	–	–	–	Dibenzofuran	Kidney	1.10E-01	–	2.84E-01	3.94E-01
			Naphthalene	–	–	–	–	Naphthalene	Weight Loss	1.79E+00	–	9.82E-01	2.77E+00
			Phenol	–	–	–	–	Phenol	Fetal Weight	8.68E-01	–	3.44E-02	9.02E-01
			Acetone	–	–	–	–	Acetone	Liver/Kidney	1.15E-01	–	4.15E-04	1.16E-01
			Benzene	6.81E-05	–	4.78E-06	7.29E-05	Benzene	Blood/Immune	2.29E+00	–	1.01E-01	2.44E+00
			Chloroform	1.76E-07	–	9.07E-09	1.85E-07	Chloroform	Liver	8.44E-03	–	3.68E-04	8.82E-03
			(Total)	4.92E-04	–	5.81E-05	4.98E-04	(Total)		1.91E+02	–	1.82E+01	2.10E+02
	Air	Contact (Inh.) with Airborne Vapors from Groundwater (Center of Plume)	Arsenic	–	NA	–	–	Arsenic	N/A	–	–	–	–
			Barium	–	–	–	–	Barium	Fetotoxicity	–	NA	–	–
			Beryllium	–	NA	–	–	Beryllium	Respiratory/Immune	–	NA	–	–
			Chromium	–	NA	–	–	Chromium	Lung	–	NA	–	–
			Cyanide	–	–	–	–	Cyanide	N/A	–	–	–	–
			Iron	–	–	–	–	Iron	N/A	–	–	–	–
			Lead	–	–	–	–	Lead	N/A	–	–	–	–
			Manganese	–	–	–	–	Manganese	CNS	–	NA	–	–
			Selenium	–	–	–	–	Selenium	N/A	–	–	–	–
			2,4-Dimethylphenol	–	–	–	–	2,4-Dimethylphenol	N/A	–	–	–	–
			2-Methylphenol	–	–	–	–	2-Methylphenol	N/A	–	–	–	–
			4-Methylphenol	–	–	–	–	4-Methylphenol	N/A	–	–	–	–
			Dibenzofuran	–	–	–	–	Dibenzofuran	N/A	–	–	–	–
			Naphthalene	–	–	–	–	Naphthalene	Respiratory	–	4.48E+01	–	4.48E+01
			Phenol	–	–	–	–	Phenol	N/A	–	–	–	–
			Acetone	–	–	–	–	Acetone	N/A	–	–	–	–
			Benzene	–	1.28E-04	–	1.28E-04	Benzene	Blood	–	7.43E+00	–	7.43E+00
			Chloroform	–	3.65E-08	–	3.65E-08	Chloroform	Respiratory	–	1.53E+00	–	1.53E+00
			(Total)	–	1.28E-04	–	1.28E-04	(Total)		–	5.38E+01	–	5.38E+01
Surface Soil	Surface Soil	Contact (Ing. & Der.) with Surface Soil (SS-1 + SS-2)	Aluminum*	–	–	–	–	Aluminum*	CNS (Developmental)	1.33E-02	–	3.49E-04	1.36E-02
			Iron*	–	–	–	–	Iron*	Liver/Blood/GI Tract	2.38E-01	–	1.66E-03	2.38E-01
			Manganese*	–	–	–	–	Manganese*	CNS	1.11E-01	–	7.89E-04	1.12E-01
			(Total)	–	–	–	–	(Total)		3.60E-01	–	2.81E-03	3.63E-01
	Particulates	Contact (Inh.) with Particulates from Surface Soil (SS-1 + SS-2)	Aluminum*	–	–	–	–	Aluminum*	CNS	–	6.91E-01	–	6.91E-01
			Iron*	–	–	–	–	Iron*	N/A	–	–	–	–
			Manganese*	–	–	–	–	Manganese*	CNS	–	9.66E+00	–	9.66E+00
			(Total)	–	–	–	–	(Total)		–	1.04E+01	–	1.04E+01
						Total Risk Across Groundwater	6.27E-04					Total Hazard Index Across Groundwater	2.64E+02
						Total Risk Across Surface Soil	–					Total Hazard Index Across Surface Soil	1.07E+01
						Total Risk Across All Media and All Exposure Routes	6.27E-04					Total Hazard Index Across All Media and All Exposure Routes	2.74E+02

Total Blood HI =	1.75E+01
Total CNS HI =	2.02E+02
Total CNS (Developmental) HI =	1.36E-02
Total Fetal Weight HI =	9.02E-01
Total Fetotoxicity HI =	–
Total GI Tract HI =	6.62E+00
Total Immune HI =	2.44E+00
Total Kidney HI =	1.79E+00
Total Liver HI =	6.33E+00
Total Lung HI =	1.48E+02
Total Nervous System HI =	1.54E+00
Total Respiratory HI =	4.64E+01
Total Skin HI =	3.29E+00
Total Thyroid HI =	1.54E+00
Total Vascular HI =	2.76E+00
Total Weight Loss HI =	1.56E+02

Notes:
* = Aluminum, iron, and manganese appear to be below background, however, the sample size is small and the background comparison test has very little power.

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SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - LIFETIME RESIDENT T SURE TO SS-01 + SS-02 SURFACE SOIL AND GROUNDWATER (CENTER OF PLUME)
REASONABLE MAXIMUM EXPOSURE
CRATER RESOURCES

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk			
				Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Contact (Ing. & Der.) with Groundwater (Center of Plume)	Arsenic	7.12E-04	–	1.44E-06	7.14E-04
			Barium	–	–	–	–
			Beryllium	–	–	–	–
			Chromium	–	–	–	–
			Cyanide	–	–	–	–
			Iron	–	–	–	–
			Lead	–	–	–	–
			Manganese	–	–	–	–
			Selenium	–	–	–	–
			2,4-Dimethylphenol	–	–	–	–
			2-Methylphenol	–	–	–	–
			4-Methylphenol	–	–	–	–
			Dibenzofuran	–	–	–	–
			Naphthalene	–	–	–	–
			Phenol	–	–	–	–
			Acetone	–	–	–	–
			Benzene	1.14E-04	–	8.62E-06	1.22E-04
			Chloroform	2.96E-07	–	1.37E-08	3.10E-07
			(Total)	8.27E-04	–	1.01E-05	8.37E-04
	Air	Contact (Inh.) with Airborne Vapors from Groundwater (Center of Plume)	Arsenic	–	–	–	–
			Barium	–	–	–	–
			Beryllium	–	–	–	–
			Chromium	–	–	–	–
			Cyanide	–	–	–	–
			Iron	–	–	–	–
			Lead	–	–	–	–
			Manganese	–	–	–	–
			Selenium	–	–	–	–
			2,4-Dimethylphenol	–	–	–	–
			2-Methylphenol	–	–	–	–
			4-Methylphenol	–	–	–	–
			Dibenzofuran	–	–	–	–
			Naphthalene	–	–	–	–
			Phenol	–	–	–	–
			Acetone	–	–	–	–
			Benzene	–	1.28E-04	–	1.28E-04
			Chloroform	–	3.65E-08	–	3.65E-08
			(Total)	–	1.28E-04	–	1.28E-04
Surface Soil	Surface Soil	Contact (Ing. & Der.) with Surface Soil (SS-1 + SS-2)	Aluminum*	–	–	–	–
			Iron*	–	–	–	–
			Manganese*	–	–	–	–
			(Total)	–	–	–	–
	Particulates	Contact (Inh.) with Particulates from Surface Soil (SS-1 + SS-2)	Aluminum*	–	–	–	–
			Iron*	–	–	–	–
			Manganese*	–	–	–	–
			(Total)	–	–	–	–
						Total Risk Across Groundwater	9.65E-04
						Total Risk Across Surface Soil	–
						Total Risk Across All Media and All Exposure Routes	9.65E-04

Chemical	Non-Carcinogenic Hazard Quotient				
	Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Arsenic	N/A	N/A	–	N/A	–
Barium	N/A	N/A	–	N/A	–
Beryllium	N/A	N/A	–	N/A	–
Chromium	N/A	N/A	–	N/A	–
Cyanide	N/A	N/A	–	N/A	–
Iron	N/A	N/A	–	N/A	–
Lead	N/A	N/A	–	N/A	–
Manganese	N/A	N/A	–	N/A	–
Selenium	N/A	N/A	–	N/A	–
2,4-Dimethylphenol	N/A	N/A	–	N/A	–
2-Methylphenol	N/A	N/A	–	N/A	–
4-Methylphenol	N/A	N/A	–	N/A	–
Dibenzofuran	N/A	N/A	–	N/A	–
Naphthalene	N/A	N/A	–	N/A	–
Phenol	N/A	N/A	–	N/A	–
Acetone	N/A	N/A	–	N/A	–
Benzene	N/A	N/A	–	N/A	–
Chloroform	N/A	N/A	–	N/A	–
(Total)		–	–	–	–
Arsenic	N/A	–	N/A	–	–
Barium	N/A	–	N/A	–	–
Beryllium	N/A	–	N/A	–	–
Chromium	N/A	–	N/A	–	–
Cyanide	N/A	–	N/A	–	–
Iron	N/A	–	N/A	–	–
Lead	N/A	–	N/A	–	–
Manganese	N/A	–	N/A	–	–
Selenium	N/A	–	N/A	–	–
2,4-Dimethylphenol	N/A	–	N/A	–	–
2-Methylphenol	N/A	–	N/A	–	–
4-Methylphenol	N/A	–	N/A	–	–
Dibenzofuran	N/A	–	N/A	–	–
Naphthalene	N/A	–	N/A	–	–
Phenol	N/A	–	N/A	–	–
Acetone	N/A	–	N/A	–	–
Benzene	N/A	–	N/A	–	–
Chloroform	N/A	–	N/A	–	–
(Total)		–	–	–	–
Aluminum*	N/A	N/A	–	N/A	–
Iron*	N/A	N/A	–	N/A	–
Manganese*	N/A	N/A	–	N/A	–
(Total)		–	–	–	–
Aluminum*	N/A	–	N/A	–	–
Iron*	N/A	–	N/A	–	–
Manganese*	N/A	–	N/A	–	–
(Total)		–	–	–	–
				Total Hazard Index Across Groundwater	–
				Total Hazard Index Across Surface Soil	–
				Total Hazard Index Across All Media and All Exposure Routes	–

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Notes:
* = Aluminum, iron, and manganese appear to be below background, however, the sample size is small and the background comparison test has very little power.

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TABLE 4
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - ADULT INDUSTRIAL WORKER EXPOSURE TO SS-01 + SS-02 SURFACE SOIL AND GROUNDWATER (CENTER OF PLUME)
REASONABLE MAXIMUM EXPOSURE
CRATER RESOURCES

Scenario Timeframe: Current
Receptor Population: Industrial Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Contact (Ing. & Der.) with Groundwater (Center of Plume)	Arsenic	1.58E-04	--	3.29E-08	1.58E-04	Arsenic	Skin/Vascular	9.82E-01	--	2.05E-04	9.82E-01
			Barium	--	--	--	--	Barium	Kidney	9.97E-02	--	1.99E-06	9.97E-02
			Beryllium	--	--	--	--	Beryllium	GI Tract	1.21E-01	--	2.41E-03	1.24E-01
			Chromium	--	--	--	--	Chromium	Kidney	2.92E-01	--	5.78E-03	2.97E-01
			Cyanide	--	--	--	--	Cyanide	Thyroid/Nervous System/Weight Loss	5.48E-01	--	1.09E-04	5.48E-01
			Iron	--	--	--	--	Iron	Liver/Blood/GI Tract	2.13E+00	--	4.22E-04	2.13E+00
			Lead	--	--	--	--	Lead	N/A	--	--	--	--
			Manganese	--	--	--	--	Manganese	CNS	1.37E+01	--	2.72E-03	1.37E+01
			Selenium	--	--	--	--	Selenium	Blood/Skin/CNS	1.91E-01	--	4.21E-05	1.91E-01
			2,4-Dimethylphenol	--	--	--	--	2,4-Dimethylphenol	Blood/CNS	2.84E-01	--	2.83E-03	2.87E-01
			2-Methylphenol	--	--	--	--	2-Methylphenol	CNS/Weight Loss	1.23E+00	--	8.56E-03	1.24E+00
			4-Methylphenol	--	--	--	--	4-Methylphenol	CNS/Lung/Weight Loss	4.70E+01	--	5.01E-01	4.75E+01
			Dibenzofuran	--	--	--	--	Dibenzofuran	Kidney	3.91E-02	--	8.86E-03	4.80E-02
			Naphthalene	--	--	--	--	Naphthalene	Weight Loss	6.38E-01	--	4.38E-02	6.80E-01
			Phenol	--	--	--	--	Phenol	Fetal Weight	3.10E-01	--	1.07E-03	3.11E-01
			Acetone	--	--	--	--	Acetone	Liver/Kidney	4.11E-02	--	1.38E-05	4.11E-02
			Benzene	2.53E-05	--	2.97E-07	2.56E-05	Benzene	Blood/Immune	8.15E-01	--	9.57E-03	8.25E-01
			Chloroform	8.57E-08	--	4.39E-10	8.61E-08	Chloroform	Liver	3.01E-03	--	2.02E-05	3.03E-03
			(Total)	1.83E-04	--	3.31E-07	1.84E-04	(Total)		6.84E+01	--	5.87E-01	6.90E+01
Surface Soil	Surface Soil	Contact (Ing. & Der.) with Surface Soil (SS-1 + SS-2)	Aluminum*	--	--	--	--	Aluminum*	CNS (Developmental)	4.74E-03	--	2.42E-04	4.96E-03
			Iron*	--	--	--	--	Iron*	Liver/Blood/GI Tract	8.43E-02	--	1.16E-03	8.55E-02
			Manganese*	--	--	--	--	Manganese*	CNS	3.95E-02	--	5.46E-04	4.01E-02
			(Total)	--	--	--	--	(Total)		1.28E-01	--	1.96E-03	1.31E-01
	Particulates	Contact (Inh.) with Particulates from Surface Soil (SS-1 + SS-2)	Aluminum*	--	--	--	--	Aluminum*	CNS	--	6.52E-01	--	6.52E-01
			Iron*	--	--	--	--	Iron*	N/A	--	--	--	--
			Manganese*	--	--	--	--	Manganese*	CNS	--	9.13E+00	--	9.13E+00
			(Total)	--	--	--	--	(Total)		--	9.78E+00	--	9.78E+00
						Total Risk Across Groundwater	1.84E-04					Total Hazard Index Across Groundwater	6.90E+01
						Total Risk Across Surface Soil	--					Total Hazard Index Across Surface Soil	9.91E+00
						Total Risk Across All Media and All Exposure Routes	1.84E-04					Total Hazard Index Across All Media and All Exposure Routes	7.89E+01

Total Blood HI =	3.52E+00
Total CNS HI =	7.27E+01
Total CNS (Developmental) HI =	4.96E-03
Total Fetal Weight HI =	3.11E-01
Total GI Tract HI =	2.34E+00
Total Immune HI =	8.25E-01
Total Kidney HI =	4.86E-01
Total Liver HI =	2.26E+00
Total Lung HI =	4.75E+01
Total Nervous System HI =	5.48E-01
Total Skin HI =	1.17E+00
Total Thyroid HI =	5.48E-01
Total Vascular HI =	9.82E-01
Total Weight Loss HI =	4.90E+01

Notes
* = Aluminum, iron, and manganese appear to be below background, however,
the sample size is small and the background comparison test has very little power.

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TABLE 4
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - CHILD RESIDENT EXPOSURE TO SS-03 SURFACE SOIL AND GROUNDWATER (CENTER OF PLUME)
REASONABLE MAXIMUM EXPOSURE
CRATER RESOURCES

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Contact (Ing. & Der.) with Groundwater (Center of Plume)	Arsenic	2.88E-04	--	4.24E-07	2.88E-04	Arsenic	Skin/Vascular	7.48E+00	--	1.10E-02	7.49E+00
			Barium	--	--	--	--	Barium	Kidney	7.59E-01	--	1.08E-03	7.60E-01
			Beryllium	--	--	--	--	Beryllium	GI Tract	9.24E-01	--	1.29E-01	1.05E+00
			Chromium	--	--	--	--	Chromium	Kidney	2.22E+00	--	3.10E-01	2.53E+00
			Cyanide	--	--	--	--	Cyanide	Thyroid/Nervous System/Weight Loss	4.17E+00	--	5.83E-03	4.18E+00
			Iron	--	--	--	--	Iron	Liver/Blood/GI Tract	1.62E+01	--	2.28E-02	1.62E+01
			Lead	--	--	--	--	Lead	N/A	--	--	--	--
			Manganese	--	--	--	--	Manganese	CNS	1.04E+02	--	1.40E-01	1.04E+02
			Selenium	--	--	--	--	Selenium	Blood/Skin/CNS	1.40E+00	--	2.29E-03	1.40E+00
			2,4-Dimethylphenol	--	--	--	--	2,4-Dimethylphenol	Blood/CNS	2.16E+00	--	1.52E-01	2.31E+00
			2-Methylphenol	--	--	--	--	2-Methylphenol	CNS/Weight Loss	9.39E+00	--	4.58E-01	9.85E+00
			4-Methylphenol	--	--	--	--	4-Methylphenol	CNS/Lung/Weight Loss	3.58E+02	--	2.68E+01	3.85E+02
			Dibenzofuran	--	--	--	--	Dibenzofuran	Kidney	2.98E-01	--	4.76E-01	7.74E-01
			Naphthalene	--	--	--	--	Naphthalene	Weight Loss	4.84E+00	--	2.35E+00	7.19E+00
			Phenol	--	--	--	--	Phenol	Fetal Weight	2.36E+00	--	5.70E-02	2.42E+00
			Acetone	--	--	--	--	Acetone	Liver/Kidney	3.13E-01	--	7.30E-04	3.14E-01
			Benzene	4.63E-05	--	3.83E-06	5.01E-05	Benzene	Blood/Immune	6.21E+00	--	5.14E-01	6.72E+00
			Chloroform	1.20E-07	--	5.08E-09	1.20E-07	Chloroform	Liver	2.30E-02	--	1.00E-03	2.40E-02
			(Total)	3.35E-04	--	4.26E-06	3.39E-04	(Total)		5.21E+02	--	3.15E+01	5.52E+02
Surface Soil	Surface Soil	Contact (Ing. & Der.) with Surface Soil (SS-3)	Arsenic*	1.31E-05	--	2.07E-07	1.33E-05	Arsenic*	Skin/Vascular	3.39E-01	--	5.37E-03	3.44E-01
			Iron	--	--	--	--	Iron	Liver/Blood/GI Tract	2.50E+00	--	1.17E-02	2.51E+00
			Manganese*	--	--	--	--	Manganese*	CNS	2.49E-01	--	1.17E-03	2.50E-01
			Benzo(a)pyrene	4.77E-05	--	--	4.77E-05	Benzo(a)pyrene	N/A	--	--	--	--
			(Total)	6.08E-05	--	2.07E-07	6.10E-05	(Total)		3.08E+00	--	1.83E-02	3.11E+00
	Particulates	Contact (Inh.) with Particulates from Surface Soil (SS-3)	Arsenic*	--	2.47E-06	--	2.47E-06	Arsenic*	N/A	--	--	--	--
			Iron	--	--	--	--	Iron	N/A	--	--	--	--
			Manganese*	--	--	--	--	Manganese*	CNS	--	7.83E+00	--	7.83E+00
			Benzo(a)pyrene	--	3.80E-07	--	3.80E-07	Benzo(a)pyrene	N/A	--	--	--	--
			(Total)	--	2.85E-06	--	2.85E-06	(Total)		--	7.83E+00	--	7.83E+00

Total Risk Across Groundwater	3.39E-04
Total Risk Across Surface Soil	6.38E-05
Total Risk Across All Media and All Exposure Routes	4.03E-04

Total Hazard Index Across Groundwater	5.52E+02
Total Hazard Index Across Surface Soil	1.09E+01
Total Hazard Index Across All Media and All Exposure Routes	5.63E+02

Total Blood HI =	2.92E+01
Total CNS HI =	5.11E+02
Total Fetal Weight HI =	2.42E+00
Total GI Tract HI =	1.98E+01
Total Immune HI =	6.72E+00
Total Kidney HI =	4.38E+00
Total Liver HI =	1.91E+01
Total Lung HI =	3.85E+02
Total Nervous System HI =	4.18E+00
Total Skin HI =	9.29E+00
Total Thyroid HI =	4.18E+00
Total Vascular HI =	7.83E+00
Total Weight Loss HI =	4.06E+02

Notes
* = Arsenic and manganese appear to be below background, however, the sample size is small and the background comparison test has very little power.

TABLE 4
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - ADULT RESIDENT EXPOSURE TO SS-03 SURFACE SOIL AND GROUNDWATER (CENTER OF PLUME)
REASONABLE MAXIMUM EXPOSURE
CRATER RESOURCES

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk: Ingestion	Carcinogenic Risk: Inhalation	Carcinogenic Risk: Dermal	Carcinogenic Risk: Exposure Routes Total	Chemical	Non-Carcinogenic Hazard Quotient: Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Contact (Ing. & Der.) with Groundwater (Center of Plume)											
			Arsenic	4.24E-04	–	1.01E-06	4.25E-04	Arsenic	Skin/Vascular	2.75E+00	–	6.58E-03	2.76E+00
			Barium	–	–	–	–	Barium	Kidney	2.75E-01	–	6.33E-04	2.80E-01
			Beryllium	–	–	–	–	Beryllium	GI Tract	3.40E-01	–	7.71E-02	4.17E-01
			Chromium	–	–	–	–	Chromium	Kidney	8.16E-01	–	1.85E-01	1.00E+00
			Cyanide	–	–	–	–	Cyanide	Thyroid/Nervous System/Weight Loss	1.53E+00	–	3.48E-03	1.54E+00
			Iron	–	–	–	–	Iron	Liver/Blood/GI Tract	5.86E+00	–	1.38E-02	5.87E+00
			Lead	–	–	–	–	Lead	N/A	–	–	–	–
			Manganese	–	–	–	–	Manganese	CNS	3.84E+01	–	8.70E-02	3.84E+01
			Selenium	–	–	–	–	Selenium	Blood/Skin/CNS	5.36E-01	–	1.38E-03	5.37E-01
			2,4-Dimethylphenol	–	–	–	–	2,4-Dimethylphenol	Blood/CNS	7.95E-01	–	9.08E-02	8.86E-01
			2-Methylphenol	–	–	–	–	2-Methylphenol	CNS/Weight Loss	3.45E+00	–	2.74E-01	3.73E+00
			4-Methylphenol	–	–	–	–	4-Methylphenol	CNS/Lung/Weight Loss	1.32E+02	–	1.60E+01	1.48E+02
			Dibenzofuran	–	–	–	–	Dibenzofuran	Kidney	1.10E-01	–	2.84E-01	3.94E-01
			Naphthalene	–	–	–	–	Naphthalene	Weight Loss	1.78E+00	–	9.93E-01	2.77E+00
			Phenol	–	–	–	–	Phenol	Fetal Weight	8.68E-01	–	3.44E-02	9.02E-01
			Acetone	–	–	–	–	Acetone	Liver/Kidney	1.15E-01	–	4.19E-04	1.16E-01
			Benzene	6.81E-05	–	4.70E-06	7.28E-05	Benzene	Blood/Immune	2.29E+00	–	1.51E-01	2.44E+00
			Chloroform	1.78E-07	–	8.07E-09	1.85E-07	Chloroform	Liver	8.44E-03	–	3.88E-04	8.82E-03
			(Total)	4.92E-04	–	5.81E-06	4.98E-04	(Total)		1.91E+02	–	1.82E+01	2.10E+02
	Air	Contact (Inh.) with Airborne Vapors from Groundwater (Center of Plume)											
			Arsenic	–	NA	–	–	Arsenic	N/A	–	–	–	–
			Barium	–	–	–	–	Barium	Fetotoxicity	–	NA	–	–
			Beryllium	–	NA	–	–	Beryllium	Respiratory/Immune	–	NA	–	–
			Chromium	–	NA	–	–	Chromium	Lung	–	NA	–	–
			Cyanide	–	–	–	–	Cyanide	N/A	–	–	–	–
			Iron	–	–	–	–	Iron	N/A	–	–	–	–
			Lead	–	–	–	–	Lead	N/A	–	–	–	–
			Manganese	–	–	–	–	Manganese	CNS	–	NA	–	–
			Selenium	–	–	–	–	Selenium	N/A	–	–	–	–
			2,4-Dimethylphenol	–	–	–	–	2,4-Dimethylphenol	N/A	–	–	–	–
			2-Methylphenol	–	–	–	–	2-Methylphenol	N/A	–	–	–	–
			4-Methylphenol	–	–	–	–	4-Methylphenol	N/A	–	–	–	–
			Dibenzofuran	–	–	–	–	Dibenzofuran	N/A	–	–	–	–
			Naphthalene	–	–	–	–	Naphthalene	Respiratory	–	4.48E+01	–	4.48E+01
			Phenol	–	–	–	–	Phenol	N/A	–	–	–	–
			Acetone	–	–	–	–	Acetone	N/A	–	–	–	–
			Benzene	–	1.26E-04	–	1.26E-04	Benzene	Blood	–	7.43E+00	–	7.43E+00
			Chloroform	–	3.65E-08	–	3.65E-08	Chloroform	Respiratory	–	1.53E+00	–	1.53E+00
			(Total)	–	1.26E-04	–	1.26E-04	(Total)		–	5.38E+01	–	5.38E+01
Surface Soil	Surface Soil	Contact (Ing. & Der.) with Surface Soil (SS-3)											
			Arsenic*	6.20E-06	–	1.48E-07	6.35E-06	Arsenic*	Skin/Vascular	4.02E-02	–	8.61E-04	4.11E-02
			Iron	–	–	–	–	Iron	Liver/Blood/GI Tract	2.88E-01	–	2.10E-03	2.90E-01
			Manganese*	–	–	–	–	Manganese*	CNS	2.85E-02	–	2.16E-04	2.87E-02
			Benzo(a)pyrene	2.28E-05	–	–	2.28E-05	Benzo(a)pyrene	N/A	–	–	–	–
			(Total)	2.90E-05	–	1.48E-07	2.90E-05	(Total)		3.56E-01	–	3.27E-03	3.60E-01
	Particulates	Contact (Inh.) with Particulates from Surface Soil (SS-3)											
			Arsenic*	–	3.25E-06	–	3.25E-06	Arsenic*	N/A	–	–	–	–
			Iron	–	–	–	–	Iron	N/A	–	–	–	–
			Manganese*	–	–	–	–	Manganese*	CNS	–	2.59E+00	–	2.59E+00
			Benzo(a)pyrene	–	5.00E-07	–	5.00E-07	Benzo(a)pyrene	N/A	–	–	–	–
			(Total)	–	3.75E-06	–	3.75E-06	(Total)		–	2.59E+00	–	2.59E+00

Total Risk Across Groundwater	6.27E-04
Total Risk Across Surface Soil	3.27E-05
Total Risk Across All Media and All Exposure Routes	6.60E-04
Total Hazard Index Across Groundwater	2.64E+02
Total Hazard Index Across Surface Soil	2.95E+00
Total Hazard Index Across All Media and All Exposure Routes	2.66E+02

Total Blood HI =	1.76E+01
Total CNS HI =	1.94E+02
Total Fetal Weight HI =	9.02E-01
Total Fetotoxicity HI =	–
Total GI Tract HI =	6.66E+00
Total Immune HI =	2.44E+00
Total Kidney HI =	1.79E+00
Total Liver HI =	6.38E+00
Total Lung HI =	1.48E+02
Total Nervous System HI =	1.54E+00
Total Respiratory HI =	4.64E+01
Total Skin HI =	3.33E+00
Total Thyroid HI =	1.54E+00
Total Vascular HI =	2.80E+00
Total Weight Loss HI =	1.56E+02

Notes
* = Arsenic and manganese appear to be below background, however,
the sample size is small and the background comparison test has very little power.

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AR306472

SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - LIFETIME RESIDENT EXPOSURE TO SS-03 SURFACE SOIL AND GROUNDWATER (CENTER OF PLUME)
REASONABLE MAXIMUM EXPOSURE
CRATER RESOURCES

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Contact (Ing. & Der.) with Groundwater (Center of Plume)	Arsenic	7.12E-04	–	1.44E-06	7.14E-04	Arsenic	N/A	N/A	–	N/A	–
			Barium	–	–	–	–	Barium	N/A	N/A	–	N/A	–
			Beryllium	–	–	–	–	Beryllium	N/A	N/A	–	N/A	–
			Chromium	–	–	–	–	Chromium	N/A	N/A	–	N/A	–
			Cyanide	–	–	–	–	Cyanide	N/A	N/A	–	N/A	–
			Iron	–	–	–	–	Iron	N/A	N/A	–	N/A	–
			Lead	–	–	–	–	Lead	N/A	N/A	–	N/A	–
			Manganese	–	–	–	–	Manganese	N/A	N/A	–	N/A	–
			Selenium	–	–	–	–	Selenium	N/A	N/A	–	N/A	–
			2,4-Dimethylphenol	–	–	–	–	2,4-Dimethylphenol	N/A	N/A	–	N/A	–
			2-Methylphenol	–	–	–	–	2-Methylphenol	N/A	N/A	–	N/A	–
			4-Methylphenol	–	–	–	–	4-Methylphenol	N/A	N/A	–	N/A	–
			Dibenzofuran	–	–	–	–	Dibenzofuran	N/A	N/A	–	N/A	–
			Naphthalene	–	–	–	–	Naphthalene	N/A	N/A	–	N/A	–
			Phenol	–	–	–	–	Phenol	N/A	N/A	–	N/A	–
			Acetone	–	–	–	–	Acetone	N/A	N/A	–	N/A	–
			Benzene	1.14E-04	–	8.82E-06	1.23E-04	Benzene	N/A	N/A	–	N/A	–
			Chloroform	2.98E-07	–	1.37E-08	3.10E-07	Chloroform	N/A	N/A	–	N/A	–
			(Total)	8.27E-04	–	1.01E-05	8.37E-04	(Total)		–	–	–	–
	Air	Contact (Inh.) with Airborne Vapors from Groundwater (Center of Plume)	Arsenic	–	–	–	–	Arsenic	N/A	–	N/A	–	–
			Barium	–	–	–	–	Barium	N/A	–	N/A	–	–
			Beryllium	–	–	–	–	Beryllium	N/A	–	N/A	–	–
			Chromium	–	–	–	–	Chromium	N/A	–	N/A	–	–
			Cyanide	–	–	–	–	Cyanide	N/A	–	N/A	–	–
			Iron	–	–	–	–	Iron	N/A	–	N/A	–	–
			Lead	–	–	–	–	Lead	N/A	–	N/A	–	–
			Manganese	–	–	–	–	Manganese	N/A	–	N/A	–	–
			Selenium	–	–	–	–	Selenium	N/A	–	N/A	–	–
			2,4-Dimethylphenol	–	–	–	–	2,4-Dimethylphenol	N/A	–	N/A	–	–
			2-Methylphenol	–	–	–	–	2-Methylphenol	N/A	–	N/A	–	–
			4-Methylphenol	–	–	–	–	4-Methylphenol	N/A	–	N/A	–	–
			Dibenzofuran	–	–	–	–	Dibenzofuran	N/A	–	N/A	–	–
			Naphthalene	–	–	–	–	Naphthalene	N/A	–	N/A	–	–
			Phenol	–	–	–	–	Phenol	N/A	–	N/A	–	–
			Acetone	–	–	–	–	Acetone	N/A	–	N/A	–	–
			Benzene	–	1.28E-04	–	1.28E-04	Benzene	N/A	–	N/A	–	–
			Chloroform	–	3.85E-06	–	3.86E-06	Chloroform	N/A	–	N/A	–	–
			(Total)	–	1.29E-04	–	1.29E-04	(Total)		–	–	–	–
Surface Soil	Surface Soil	Contact (Ing. & Der.) with Surface Soil (SS-3)	Arsenic*	1.93E-06	–	3.56E-07	1.98E-06	Arsenic*	N/A	N/A	–	N/A	–
			Iron	–	–	–	–	Iron	N/A	N/A	–	N/A	–
			Manganese*	–	–	–	–	Manganese*	N/A	N/A	–	N/A	–
			Benzo(a)pyrene	7.93E-05	–	–	7.03E-05	Benzo(a)pyrene	N/A	N/A	–	N/A	–
			(Total)	8.96E-05	–	3.55E-07	9.00E-05	(Total)		–	–	–	–
	Particulates	Contact (Inh.) with Particulates from Surface Soil (SS-3)	Arsenic*	–	5.72E-08	–	5.72E-08	Arsenic*	N/A	–	N/A	–	–
			Iron	–	–	–	–	Iron	N/A	–	N/A	–	–
			Manganese*	–	–	–	–	Manganese*	N/A	–	N/A	–	–
			Benzo(a)pyrene	–	8.80E-07	–	8.80E-07	Benzo(a)pyrene	N/A	–	N/A	–	–
			(Total)	–	6.60E-06	–	6.60E-06	(Total)		–	–	–	–

Total Risk Across Groundwater	9.65E-04
Total Risk Across Surface Soil	9.06E-05
Total Risk Across All Media and All Exposure Routes	1.06E-03

Total Hazard Index Across Groundwater	–
Total Hazard Index Across Surface Soil	–
Total Hazard Index Across All Media and All Exposure Routes	–

Notes
* = Arsenic and manganese appear to be below background, however, the sample size is small and the background comparison test has very little power.

AR306473

TABLE 4
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - ADULT INDUSTRIAL WORKER EXPOSURE TO SS-03 SURFACE SOIL AND GROUNDWATER (CENTER OF PLUME)
REASONABLE MAXIMUM EXPOSURE
CRATER RESOURCES

Scenario Timeframe: Current
Receptor Population: Industrial Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Contact (Ing. & Der.) with Groundwater (Center of Plume)											
			Arsenic	1.58E-04	--	3.29E-06	1.58E-04	Arsenic	Skin/Vascular	9.82E-01	--	2.05E-04	9.82E-01
			Barium	--	--	--	--	Barium	Kidney	9.97E-02	--	1.88E-05	9.97E-02
			Beryllium	--	--	--	--	Beryllium	GI Tract	1.21E-01	--	2.41E-03	1.24E-01
			Chromium	--	--	--	--	Chromium	Kidney	2.92E-01	--	5.78E-03	2.97E-01
			Cyanide	--	--	--	--	Cyanide	Thyroid/Nervous System/Weight Loss	5.48E-01	--	1.08E-04	5.48E-01
			Iron	--	--	--	--	Iron	Liver/Blood/GI Tract	2.13E+00	--	4.22E-04	2.13E+00
			Lead	--	--	--	--	Lead	N/A	--	--	--	--
			Manganese	--	--	--	--	Manganese	CNS	1.37E+01	--	2.72E-03	1.37E+01
			Selenium	--	--	--	--	Selenium	Blood/Skin/CNS	1.91E-01	--	4.21E-05	1.91E-01
			2,4-Dimethylphenol	--	--	--	--	2,4-Dimethylphenol	Blood/CNS	2.84E-01	--	2.83E-03	2.87E-01
			2-Methylphenol	--	--	--	--	2-Methylphenol	CNS/Weight Loss	1.22E+00	--	8.55E-03	1.24E+00
			4-Methylphenol	--	--	--	--	4-Methylphenol	CNS/Lung/Weight Loss	4.70E+01	--	5.01E-01	4.75E+01
			Dibenzofuran	--	--	--	--	Dibenzofuran	Kidney	3.91E-02	--	8.86E-03	4.80E-02
			Naphthalene	--	--	--	--	Naphthalene	Weight Loss	6.36E-01	--	4.38E-02	6.80E-01
			Phenol	--	--	--	--	Phenol	Fetal Weight	3.10E-01	--	1.07E-03	3.11E-01
			Acetone	--	--	--	--	Acetone	Liver/Kidney	4.11E-02	--	1.38E-05	4.11E-02
			Benzene	2.53E-05	--	2.87E-07	2.56E-05	Benzene	Blood/Immune	8.15E-01	--	9.57E-03	8.25E-01
			Chloroform	6.57E-08	--	4.36E-10	6.61E-08	Chloroform	Liver	3.01E-03	--	2.02E-05	3.03E-03
			(Total)	1.83E-04	--	3.31E-07	1.84E-04	(Total)		6.84E+01	--	5.87E-01	6.90E+01
Surface Soil	Surface Soil	Contact (Ing. & Der.) with Surface Soil (SS-3)											
			Arsenic*	2.31E-06	--	1.07E-07	2.41E-06	Arsenic*	Skin/Vascular	1.44E-02	--	6.67E-04	1.50E-02
			Iron	--	--	--	--	Iron	Liver/Blood/GI Tract	1.06E-01	--	1.46E-03	1.07E-01
			Manganese*	--	--	--	--	Manganese*	CNS	1.05E-02	--	1.45E-04	1.07E-02
			Benzo(a)pyrene	8.42E-06	--	--	8.42E-06	Benzo(a)pyrene	N/A	--	--	--	--
			(Total)	1.07E-05	--	1.07E-07	1.08E-05	(Total)		1.31E-01	--	2.27E-03	1.33E-01
	Particulates	Contact (Inh.) with Particulates from Surface Soil (SS-3)											
			Arsenic*	--	3.19E-08	--	3.19E-08	Arsenic*	N/A	--	--	--	--
			Iron	--	--	--	--	Iron	N/A	--	--	--	--
			Manganese*	--	--	--	--	Manganese*	CNS	--	2.43E+00	--	2.43E+00
			Benzo(a)pyrene	--	4.92E-07	--	4.92E-07	Benzo(a)pyrene	N/A	--	--	--	--
			(Total)	--	3.68E-06	--	3.68E-06	(Total)		--	2.43E+00	--	2.43E+00

Total Risk Across Groundwater	1.84E-04
Total Risk Across Surface Soil	1.45E-05
Total Risk Across All Media and All Exposure Routes	1.96E-04

Total Hazard Index Across Groundwater	6.90E+01
Total Hazard Index Across Surface Soil	2.57E+00
Total Hazard Index Across All Media and All Exposure Routes	7.15E+01

Total Blood HI =	3.54E+00
Total CNS HI =	6.53E+01
Total Fetal Weight HI =	3.11E-01
Total GI Tract HI =	2.36E+00
Total Immune HI =	8.25E-01
Total Kidney HI =	4.86E-01
Total Liver HI =	2.28E+00
Total Lung HI =	4.75E+01
Total Nervous System HI =	5.48E-01
Total Skin HI =	1.19E+00
Total Thyroid HI =	5.48E-01
Total Vascular HI =	9.97E-01
Total Weight Loss HI =	4.99E+01

Notes
* = Arsenic and manganese appear to be below background, however,
the sample size is small and the background comparison test has very little power.

AR306474

UMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - CHILD RESIDENT EXPOSURE TO YE T PARCEL (PIPELINE AREA) SURFACE SOIL, SEDIMENT, AND GROUNDWATER (CENTER OF PLUM
REASONABLE MAXIMUM EXPOSURE
CRATER RESOURCES

Scenario Timeframe:	Future
Receptor Population:	Resident
Receptor Age:	Child

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Contact (Ing. & Der.) with Groundwater (Center of Plume)	Arsenic	2.88E-04	–	4.24E-07	2.88E-04	Arsenic	Skin/Vascular	7.40E+00	–	1.10E-02	7.40E+00
			Barium	–	–	–	–	Barium	Kidney	7.50E-01	–	1.08E-03	7.60E-01
			Beryllium	–	–	–	–	Beryllium	GI Tract	9.24E-01	–	1.28E-01	1.05E+00
			Chromium	–	–	–	–	Chromium	Kidney	2.22E+00	–	3.10E-01	2.53E+00
			Cyanide	–	–	–	–	Cyanide	Thyroid/Nervous System/Weight Loss	4.17E+00	–	5.83E-03	4.18E+00
			Iron	–	–	–	–	Iron	Liver/Blood/GI Tract	1.62E+01	–	2.20E-02	1.62E+01
			Lead	–	–	–	–	Lead	N/A	–	–	–	–
			Manganese	–	–	–	–	Manganese	CNS	1.04E+02	–	1.40E-01	1.04E+02
			Selenium	–	–	–	–	Selenium	Blood/Skin/CNS	1.40E+00	–	2.20E-03	1.40E+00
			2,4-Dimethylphenol	–	–	–	–	2,4-Dimethylphenol	Blood/CNS	2.16E+00	–	1.52E-01	2.31E+00
			2-Methylphenol	–	–	–	–	2-Methylphenol	CNS/Weight Loss	9.30E+00	–	4.50E-01	9.85E+00
			4-Methylphenol	–	–	–	–	4-Methylphenol	CNS/Lung/Weight Loss	3.58E+02	–	2.60E+01	3.85E+02
			Dibenzofuran	–	–	–	–	Dibenzofuran	Kidney	2.98E-01	–	4.76E-01	7.74E-01
			Naphthalene	–	–	–	–	Naphthalene	Weight Loss	4.84E+00	–	2.35E+00	7.19E+00
			Phenol	–	–	–	–	Phenol	Fetal Weight	2.36E+00	–	5.76E-02	2.42E+00
			Acetone	–	–	–	–	Acetone	Liver/Kidney	3.13E-01	–	7.30E-04	3.14E-01
			Benzene	4.63E-05	–	3.83E-06	5.01E-05	Benzene	Blood/Immune	6.21E+00	–	5.14E-01	6.72E+00
			Chloroform	1.20E-07	–	5.00E-09	1.25E-07	Chloroform	Liver	2.38E-02	–	1.08E-03	2.48E-02
			(Total)	3.35E-04	–	4.28E-06	3.38E-04	(Total)		5.21E+02	–	3.15E+01	5.52E+02
Surface Soil	Surface Soil	Contact (Ing. & Der.) with Surface Soil (Yellow Parcel - Pipeline Area)	Aluminum	–	–	–	–	Aluminum	CNS (Developmental)	1.70E-01	–	2.90E-03	1.73E-01
			Arsenic	4.28E-06	–	6.77E-07	4.30E-06	Arsenic	Skin/Vascular	1.11E+00	–	1.70E-02	1.13E+00
			Chromium	–	–	–	–	Chromium	Kidney	9.84E-02	–	4.87E-02	1.48E-01
			Iron*	–	–	–	–	Iron*	Liver/Blood/GI Tract	1.14E+00	–	5.34E-03	1.14E+00
			Benz(a)anthracene	1.59E-04	–	–	1.59E-04	Benz(a)anthracene	N/A	–	–	–	–
			Benzo(a)pyrene	1.88E-03	–	–	1.88E-03	Benzo(a)pyrene	N/A	–	–	–	–
			Benzo(b)fluoranthene	3.04E-04	–	–	3.04E-04	Benzo(b)fluoranthene	N/A	–	–	–	–
			Dibenz(a,h)anthracene	6.30E-05	–	–	6.30E-05	Dibenz(a,h)anthracene	N/A	–	–	–	–
			Dibenzofuran	–	–	–	–	Dibenzofuran	Kidney	1.21E+00	–	8.14E-02	1.29E+00
			Indeno(1,2,3-cd)pyrene	4.48E-05	–	–	4.48E-05	Indeno(1,2,3-cd)pyrene	N/A	–	–	–	–
			(Total)	2.47E-03	–	6.77E-07	2.47E-03	(Total)		3.73E+00	–	1.54E-01	3.88E+00
	Particulates	Contact (Inh.) with Particulates from Surface Soil (Yellow Parcel - Pipeline Area)	Aluminum	–	–	–	–	Aluminum	CNS	–	3.18E+00	–	3.18E+00
			Arsenic	–	8.07E-06	–	8.07E-06	Arsenic	N/A	–	–	–	–
			Chromium	–	1.98E-05	–	1.98E-05	Chromium	Lung	–	1.95E-01	–	1.95E-01
			Iron*	–	–	–	–	Iron*	N/A	–	–	–	–
			Benz(a)anthracene	–	–	–	–	Benz(a)anthracene	N/A	–	–	–	–
			Benzo(a)pyrene	–	1.40E-05	–	1.40E-05	Benzo(a)pyrene	N/A	–	–	–	–
			Benzo(b)fluoranthene	–	–	–	–	Benzo(b)fluoranthene	N/A	–	–	–	–
			Dibenz(a,h)anthracene	–	–	–	–	Dibenz(a,h)anthracene	N/A	–	–	–	–
			Dibenzofuran	–	–	–	–	Dibenzofuran	N/A	–	–	–	–
			Indeno(1,2,3-cd)pyrene	–	–	–	–	Indeno(1,2,3-cd)pyrene	N/A	–	–	–	–
			(Total)	–	4.25E-05	–	4.25E-05	(Total)		–	3.38E+00	–	3.38E+00

Total Risk Across Groundwater	3.38E-04
Total Risk Across Sediment	–
Total Risk Across Surface Soil	2.51E-03
Total Risk Across All Media and All Exposure Routes	2.85E-03

Total Hazard Index Across Groundwater	5.52E+02
Total Hazard Index Across Sediment	–
Total Hazard Index Across Surface Soil	7.28E+00
Total Hazard Index Across All Media and All Exposure Routes	5.60E+02

Total Blood HI =	2.79E+01
Total CNS HI =	5.06E+02
Total CNS (Developmental) HI =	1.73E-01
Total Fetal Weight HI =	2.42E+00
Total GI Tract HI =	1.84E+01
Total Immune HI =	6.72E+00
Total Kidney HI =	5.82E+00
Total Liver HI =	1.77E+01
Total Lung HI =	3.85E+02
Total Nervous System HI =	4.18E+00
Total Skin HI =	1.01E+01
Total Thyroid HI =	4.18E+00
Total Vascular HI =	8.61E+00
Total Weight Loss HI =	4.08E+02

Notes:
* = Only the UTL test for iron indicates a background exceedance.

TABLE 4
MARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - LIFETIME RESIDENT EXPOSURE TO YELLOW PARCEL (PIPELINE AREA) SURFACE SOIL, SEDIMENT AND GROUNDWATER (CENTER OF PL
REASONABLE MAXIMUM EXPOSURE
CRATER RESOURCES

Scenario Timeframe: Future
Receptor Population: Resident
Receptor Age: Child/Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Contact (Ing. & Der.) with Groundwater (Center of Plume)	Arsenic	7.12E-04	–	1.44E-06	7.14E-04	Arsenic	NA	NA	–	NA	–
			Barium	–	–	–	–	Barium	NA	NA	–	NA	–
			Beryllium	–	–	–	–	Beryllium	NA	NA	–	NA	–
			Chromium	–	–	–	–	Chromium	NA	NA	–	NA	–
			Cyanide	–	–	–	–	Cyanide	NA	NA	–	NA	–
			Iron	–	–	–	–	Iron	NA	NA	–	NA	–
			Lead	–	–	–	–	Lead	NA	NA	–	NA	–
			Manganese	–	–	–	–	Manganese	NA	NA	–	NA	–
			Selenium	–	–	–	–	Selenium	NA	NA	–	NA	–
			2,4-Dimethylphenol	–	–	–	–	2,4-Dimethylphenol	NA	NA	–	NA	–
			2-Methylphenol	–	–	–	–	2-Methylphenol	NA	NA	–	NA	–
			4-Methylphenol	–	–	–	–	4-Methylphenol	NA	NA	–	NA	–
			Dibenzofuran	–	–	–	–	Dibenzofuran	NA	NA	–	NA	–
			Naphthalene	–	–	–	–	Naphthalene	NA	NA	–	NA	–
			Phenol	–	–	–	–	Phenol	NA	NA	–	NA	–
			Acetone	–	–	–	–	Acetone	NA	NA	–	NA	–
			Benzene	1.14E-04	–	8.62E-06	1.23E-04	Benzene	NA	NA	–	NA	–
			Chloroform	2.98E-07	–	1.37E-08	3.10E-07	Chloroform	NA	NA	–	NA	–
			(Total)	8.27E-04	–	1.01E-05	8.37E-04	(Total)		–	–	–	–
	Air	Contact (Inh.) with Airborne Vapors from Groundwater (Center of Plume)	Arsenic	–	–	–	–	Arsenic	NA	–	NA	–	–
			Barium	–	–	–	–	Barium	NA	–	NA	–	–
			Beryllium	–	–	–	–	Beryllium	NA	–	NA	–	–
			Chromium	–	–	–	–	Chromium	NA	–	NA	–	–
			Cyanide	–	–	–	–	Cyanide	NA	–	NA	–	–
			Iron	–	–	–	–	Iron	NA	–	NA	–	–
			Lead	–	–	–	–	Lead	NA	–	NA	–	–
			Manganese	–	–	–	–	Manganese	NA	–	NA	–	–
			Selenium	–	–	–	–	Selenium	NA	–	NA	–	–
			2,4-Dimethylphenol	–	–	–	–	2,4-Dimethylphenol	NA	–	NA	–	–
			2-Methylphenol	–	–	–	–	2-Methylphenol	NA	–	NA	–	–
			4-Methylphenol	–	–	–	–	4-Methylphenol	NA	–	NA	–	–
			Dibenzofuran	–	–	–	–	Dibenzofuran	N/A	–	N/A	–	–
			Naphthalene	–	–	–	–	Naphthalene	NA	–	NA	–	–
			Phenol	–	–	–	–	Phenol	NA	–	NA	–	–
			Acetone	–	–	–	–	Acetone	NA	–	NA	–	–
			Benzene	–	1.28E-04	–	1.28E-04	Benzene	NA	–	NA	–	–
			Chloroform	–	3.65E-08	–	3.65E-08	Chloroform	NA	–	NA	–	–
			(Total)	–	1.28E-04	–	1.28E-04	(Total)		–	–	–	–
Surface Soil	Surface Soil	Contact (Ing. & Der.) with Surface Soil (Yellow Parcel - Pipeline Area)	Aluminum	–	–	–	–	Aluminum	NA	NA	–	NA	–
			Arsenic	6.31E-05	–	1.10E-06	6.42E-05	Arsenic	NA	NA	–	NA	–
			Chromium	–	–	–	–	Chromium	NA	NA	–	NA	–
			Iron*	–	–	–	–	Iron*	NA	NA	–	NA	–
			Benzo(a)anthracene	2.34E-04	–	–	2.34E-04	Benzo(a)anthracene	NA	NA	–	NA	–
			Benzo(a)pyrene	2.74E-03	–	–	2.74E-03	Benzo(a)pyrene	NA	NA	–	NA	–
			Benzo(b)fluoranthene	4.40E-04	–	–	4.40E-04	Benzo(b)fluoranthene	NA	NA	–	NA	–
			Dibenz(a,h)anthracene	9.28E-05	–	–	9.28E-05	Dibenz(a,h)anthracene	NA	NA	–	NA	–
			Dibenzofuran	–	–	–	–	Dibenzofuran	NA	NA	–	NA	–
			Indeno(1,2,3-cd)pyrene	6.62E-05	–	–	6.62E-05	Indeno(1,2,3-cd)pyrene	NA	NA	–	NA	–
			(Total)	3.64E-03	–	1.10E-06	3.64E-03	(Total)		–	–	–	–
	Particulates	Contact (Inh.) with Particulates from Surface Soil (Yellow Parcel - Pipeline Area)	Aluminum	–	–	–	–	Aluminum	NA	–	NA	–	–
			Arsenic	–	1.07E-05	–	1.07E-05	Arsenic	NA	–	NA	–	–
			Chromium	–	4.55E-05	–	4.55E-05	Chromium	NA	–	NA	–	–
			Iron*	–	–	–	–	Iron*	NA	–	NA	–	–
			Benzo(a)anthracene	–	–	–	–	Benzo(a)anthracene	NA	–	NA	–	–
			Benzo(a)pyrene	–	3.43E-08	–	3.43E-08	Benzo(a)pyrene	NA	–	NA	–	–
			Benzo(b)fluoranthene	–	–	–	–	Benzo(b)fluoranthene	NA	–	NA	–	–
			Dibenz(a,h)anthracene	–	–	–	–	Dibenz(a,h)anthracene	NA	–	NA	–	–
			Dibenzofuran	–	–	–	–	Dibenzofuran	NA	–	NA	–	–
			Indeno(1,2,3-cd)pyrene	–	–	–	–	Indeno(1,2,3-cd)pyrene	NA	–	NA	–	–
			(Total)	–	9.85E-05	–	9.85E-05	(Total)		–	–	–	–

Total Risk Across Groundwater	9.65E-04
Total Risk Across Sediment	–
Total Risk Across Surface Soil	3.74E-03
Total Risk Across All Media and All Exposure Routes	4.71E-03

Total Hazard Index Across Groundwater	–
Total Hazard Index Across Sediment	–
Total Hazard Index Across Surface Soil	–
Total Hazard Index Across All Media and All Exposure Routes	–

Notes
* = Only the UTL test for iron indicates a background exceedance.

TABLE 4
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - ADOLESCENT (TEENS) TRESPASSER/VISITOR EXPOSURE TO YELLOW PARCEL (PIPELINE AREA) SURFACE SOIL AND SEDIMENT
REASONABLE MAXIMUM EXPOSURE
CRATER RESOURCES

Scenario Timeframe: Current
Receptor Population: Trespasser/Visitor
Receptor Age: Adolescent (Teens)

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Surface Soil	Surface Soil	Contact (Ing. & Der.) with Surface Soil (Yellow Parcel - Pipeline Area)											
			Aluminum	--	--	--	--	Aluminum	CNS (Developmental)	6.83E-03	--	3.67E-04	7.19E-03
			Arsenic	2.87E-06	--	1.40E-07	3.01E-06	Arsenic	Skin/Vascular	4.46E-02	--	2.18E-03	4.68E-02
			Chromium	--	--	--	--	Chromium	Kidney	3.99E-03	--	5.79E-03	9.78E-03
			Iron*	--	--	--	--	Iron*	Liver/Blood/GI Tract	4.57E-02	--	6.62E-04	4.63E-02
			Benz(a)anthracene	1.07E-05	--	--	1.07E-05	Benz(a)anthracene	N/A	--	--	--	--
			Benzo(a)pyrene	1.24E-04	--	--	1.24E-04	Benzo(a)pyrene	N/A	--	--	--	--
			Benzo(b)fluoranthene	2.03E-05	--	--	2.03E-05	Benzo(b)fluoranthene	N/A	--	--	--	--
			Dibenz(a,h)anthracene	4.22E-06	--	--	4.22E-06	Dibenz(a,h)anthracene	N/A	--	--	--	--
			Dibenzofuran	--	--	--	--	Dibenzofuran	Kidney	4.88E-02	--	1.01E-02	5.89E-02
			Indeno(1,2,3-cd)pyrene	3.01E-06	--	--	3.01E-06	Indeno(1,2,3-cd)pyrene	N/A	--	--	--	--
			(Total)	1.66E-04	--	1.40E-07	1.66E-04	(Total)		1.50E-01	--	1.91E-02	1.69E-01
	Particulates	Contact (Inh.) with Particulates from Surface Soil (Yellow Parcel - Pipeline Area)											
			Aluminum	--	--	--	--	Aluminum	CNS	--	8.53E-02	--	8.53E-02
			Arsenic	--	3.61E-07	--	3.61E-07	Arsenic	N/A	--	--	--	--
			Chromium	--	8.77E-07	--	8.77E-07	Chromium	Lung	--	5.24E-03	--	5.24E-03
			Iron*	--	--	--	--	Iron*	N/A	--	--	--	--
			Benz(a)anthracene	--	--	--	--	Benz(a)anthracene	N/A	--	--	--	--
			Benzo(a)pyrene	--	6.61E-07	--	6.61E-07	Benzo(a)pyrene	N/A	--	--	--	--
			Benzo(b)fluoranthene	--	--	--	--	Benzo(b)fluoranthene	N/A	--	--	--	--
			Dibenz(a,h)anthracene	--	--	--	--	Dibenz(a,h)anthracene	N/A	--	--	--	--
			Dibenzofuran	--	--	--	--	Dibenzofuran	N/A	--	--	--	--
			Indeno(1,2,3-cd)pyrene	--	--	--	--	Indeno(1,2,3-cd)pyrene	N/A	--	--	--	--
			(Total)	--	1.90E-06	--	1.90E-06	(Total)		--	9.06E-02	--	9.06E-02

Total Risk Across Sediment	--
Total Risk Across Surface Soil	1.68E-04
Total Risk Across All Media and All Exposure Routes	1.68E-04

Total Hazard Index Across Sediment	--
Total Hazard Index Across Surface Soil	2.59E-01
Total Hazard Index Across All Media and All Exposure Routes	2.59E-01

Total Blood HI =	4.63E-02
Total CNS HI =	9.25E-02
Total CNS (Developmental) HI =	7.19E-03
Total GI Tract HI =	4.63E-02
Total Kidney HI =	6.86E-02
Total Liver HI =	4.63E-02
Total Lung HI =	5.24E-03
Total Skin HI =	4.68E-02
Total Vascular HI =	4.68E-02

Notes
* = Only the UTL test for iron indicates a background exceedance.

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TABLE 4
Y OF RECEPTOR RISKS AND HAZARDS FOR COPCs - ADULT INDUSTRIAL WORKER EXPOSURE TO YELLOW PARCEL (PIPELINE AREA) SURFACE SOIL, SEDIMENT AND GROUNDWATER (CENTER OF
REASONABLE MAXIMUM EXPOSURE
CRATER RESOURCES

Scenario Timeframe: Current/Future
Receptor Population: Industrial Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Groundwater	Contact (Ing. & Der.) with Groundwater (Center of Plume)	Arsenic	1.58E-04	--	3.29E-08	1.58E-04	Arsenic	Skin/Vascular	9.82E-01	--	2.05E-04	9.82E-01
			Barium	--	--	--	--	Barium	Kidney	9.97E-02	--	1.96E-05	9.97E-02
			Beryllium	--	--	--	--	Beryllium	GI Tract	1.21E-01	--	2.41E-03	1.24E-01
			Chromium	--	--	--	--	Chromium	Kidney	2.92E-01	--	5.78E-03	2.97E-01
			Cyanide	--	--	--	--	Cyanide	Thyroid/Nervous System/Weight Loss	5.46E-01	--	1.08E-04	5.46E-01
			Iron	--	--	--	--	Iron	Liver/Blood/GI Tract	2.13E+00	--	4.22E-04	2.13E+00
			Lead	--	--	--	--	Lead	N/A	--	--	--	--
			Manganese	--	--	--	--	Manganese	CNS	1.37E+01	--	2.72E-03	1.37E+01
			Selenium	--	--	--	--	Selenium	Blood/Skin/CNS	1.91E-01	--	4.21E-05	1.91E-01
			2,4-Dimethylphenol	--	--	--	--	2,4-Dimethylphenol	Blood/CNS	2.84E-01	--	2.83E-03	2.87E-01
			2-Methylphenol	--	--	--	--	2-Methylphenol	CNS/Weight Loss	1.23E+00	--	8.56E-03	1.24E+00
			4-Methylphenol	--	--	--	--	4-Methylphenol	CNS/Lung/Weight Loss	4.70E+01	--	5.01E-01	4.75E+01
			Dibenzofuran	--	--	--	--	Dibenzofuran	Kidney	3.91E-02	--	8.89E-03	4.80E-02
			Naphthalene	--	--	--	--	Naphthalene	Weight Loss	6.36E-01	--	4.36E-02	6.80E-01
			Phenol	--	--	--	--	Phenol	Fetal Weight	3.10E-01	--	1.07E-03	3.11E-01
			Acetone	--	--	--	--	Acetone	Liver/Kidney	4.11E-02	--	1.36E-05	4.11E-02
			Benzene	2.53E-05	--	2.97E-07	2.56E-05	Benzene	Blood/Immune	8.16E-01	--	9.67E-03	8.26E-01
			Chloroform	6.57E-08	--	4.39E-10	6.61E-08	Chloroform	Liver	3.01E-03	--	2.02E-05	3.03E-03
			(Total)	1.83E-04	--	3.31E-07	1.84E-04	(Total)		6.84E+01	--	5.87E-01	6.90E+01
Surface Soil	Surface Soil	Contact (Ing. & Der.) with Surface Soil (Yellow Parcel - Pipeline Area)	Aluminum	--	--	--	--	Aluminum	CNS (Developmental)	7.19E-03	--	3.69E-04	7.56E-03
			Arsenic	7.55E-06	--	3.51E-07	7.90E-06	Arsenic	Skin/Vascular	4.70E-02	--	2.10E-03	4.91E-02
			Chromium	--	--	--	--	Chromium	Kidney	4.21E-03	--	5.81E-03	1.00E-02
			Iron*	--	--	--	--	Iron*	Liver/Blood/GI Tract	4.81E-02	--	6.64E-04	4.88E-02
			Benz(a)anthracene	2.81E-05	--	--	2.81E-05	Benz(a)anthracene	N/A	--	--	--	--
			Benzo(a)pyrene	3.29E-04	--	--	3.29E-04	Benzo(a)pyrene	N/A	--	--	--	--
			Benzo(b)fluoranthene	5.30E-05	--	--	5.30E-05	Benzo(b)fluoranthene	N/A	--	--	--	--
			Dibenz(a,h)anthracene	1.11E-05	--	--	1.11E-05	Dibenz(a,h)anthracene	N/A	--	--	--	--
			Dibenzofuran	--	--	--	--	Dibenzofuran	Kidney	5.14E-02	--	1.01E-02	6.15E-02
			Indeno(1,2,3-cd)pyrene	7.92E-06	--	--	7.92E-06	Indeno(1,2,3-cd)pyrene	N/A	--	--	--	--
			(Total)	4.36E-04	--	3.51E-07	4.36E-04	(Total)		1.58E-01	--	1.91E-02	1.77E-01
	Particulates	Contact (Inh.) with Particulates from Surface Soil (Yellow Parcel - Pipeline Area)	Aluminum	--	--	--	--	Aluminum	CNS	--	9.88E-01	--	9.88E-01
			Arsenic	--	1.04E-05	--	1.04E-05	Arsenic	N/A	--	--	--	--
			Chromium	--	2.54E-05	--	2.54E-05	Chromium	Lung	--	6.07E-02	--	6.07E-02
			Iron*	--	--	--	--	Iron*	N/A	--	--	--	--
			Benz(a)anthracene	--	--	--	--	Benz(a)anthracene	N/A	--	--	--	--
			Benzo(a)pyrene	--	1.91E-05	--	1.91E-05	Benzo(a)pyrene	N/A	--	--	--	--
			Benzo(b)fluoranthene	--	--	--	--	Benzo(b)fluoranthene	N/A	--	--	--	--
			Dibenz(a,h)anthracene	--	--	--	--	Dibenz(a,h)anthracene	N/A	--	--	--	--
			Dibenzofuran	--	--	--	--	Dibenzofuran	N/A	--	--	--	--
			Indeno(1,2,3-cd)pyrene	--	--	--	--	Indeno(1,2,3-cd)pyrene	N/A	--	--	--	--
			(Total)	--	5.50E-05	--	5.50E-05	(Total)		--	1.05E+00	--	1.05E+00

Total Risk Across Groundwater	1.84E-04
Total Risk Across Sediment	--
Total Risk Across Surface Soil	4.91E-04
Total Risk Across All Media and All Exposure Routes	6.75E-04

Total Hazard Index Across Groundwater	6.90E+01
Total Hazard Index Across Sediment	--
Total Hazard Index Across Surface Soil	1.23E+00
Total Hazard Index Across All Media and All Exposure Routes	7.02E+01

Notes
* = Only the UTL test for iron indicates a background exceedance.

Total Blood HI =	3.46E+00
Total CNS HI =	6.39E+01
Total CNS (Developmental) HI =	7.56E-03
Total Fetal Weight HI =	3.11E-01
Total GI Tract HI =	2.30E+00
Total Immune HI =	8.25E-01
Total Kidney HI =	5.56E-01
Total Liver HI =	2.22E+00
Total Lung HI =	4.75E+01
Total Nervous System HI =	5.46E-01
Total Skin HI =	1.22E+00
Total Thyroid HI =	5.46E-01
Total Vascular HI =	1.03E+00
Total Weight Loss HI =	4.89E+01

TABLE 4
SUMMARY OF RECEPTOR RISKS AND HAZARDS FOR COPCs - ADULT CONSTRUCTION WORKER EXPOSURE TO YELLOW PARCEL (QUARRY 4 AREA) SOIL
REASONABLE MAXIMUM EXPOSURE
CRATER RESOURCES

Scenario Timeframe: Future
Receptor Population: Construction Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	Soil	Contact (Ing. & Der.) with Soil (Yellow Parcel Quarry 4 Area)											
			Iron	--	--	--	--	Iron	Liver/Blood/GI Tract	1.25E+00	--	8.31E-03	1.26E+00
			Manganese	--	--	--	--	Manganese	CNS	4.90E-01	--	3.25E-03	4.93E-01
			(Total)	--	--	--	--	(Total)		1.74E+00	--	1.16E-02	1.75E+00
	Particulates	Contact (Inh.) with Particulates from Soil (Yellow Parcel Quarry 4 Area)											
			Iron	--	--	--	--	Iron	N/A	--	--	--	--
			Manganese	--	--	--	--	Manganese	CNS	--	1.18E+01	--	1.18E+01
			(Total)	--	--	--	--	(Total)		--	1.18E+01	--	1.18E+01
						Total Risk Across Soil	--					Total Hazard Index Across Soil	1.35E+01
						Total Risk Across All Media and All Exposure Routes	--					Total Hazard Index Across All Media and All Exposure Routes	1.35E+01

Total GI Tract HI = 1.26E+00
Total Liver HI = 1.26E+00

TABLE 5
SIGNIFICANT RISKS (HI>1.0; CANCER RISK >1E-04)

Area	Child Resident HI	Adult Resident HI	Child/Adult resident CR	Tresspasser/vistor		Construction		Industrial	
				HI	CR	HI	CR	HI	CR
Groundwater center of plume	550	260	1E-03	--	--	--	--	69	2E-04
Groundwater extent of plume	160	66	8E-04	--	--	--	--	20	2E-04
Quarry 1 soil	1.6*	--	--	--	--	6	--	--	--
Quarry 2 soil	--	--	--	--	--	4*	--	--	--
Quarry 3 sediment	3	--	2E-03	--	2E-04	--	--	--	1E-04
Quarry 3 soil	23**	4**	8E-03**	--	4E-04**	230	2E-04	2**	1E-03**
Quarry 4 soil	108**	34*	6E-04**	3*	--	21*	--	31*	3E-04**
Quarry 6 soil	--	--	--	--	--	30**	4E-03**	--	--
SS1, SS2 soil	34*	11*	--	--	--	--	--	10*	--
SS3 soil	11**	3*	1E-04**					3*	--
Yellow Parcel Pipeline	7*	--	4E-03	--	2E-04	--	--	--	5E-04
Yellow Parcel - Quary 4 soil	--	--	--	--	--	14	--	--	--

* At least one statistical test indicates that the chemicals driving this risk may be attributable to backgroud.
** Some, but not, of the chemicals contributing to this risk may be attributable to background

Table 6 *Sediment and Soil EEQs for On-Site Constituents of Potential Concern*
Crater Resources Site
Upper Merion Township, Pennsylvania

	Sediment						Soil					
Constituent	Screening Level (mg/Kg)		Maximum † Concentration (mg/Kg)	EEQ*	Frequency of Detection**	Frequency of Exceedance***	Screening Level (mg/Kg)		Maxiumum † Concentration (mg/Kg)	EEQ*	Frequency of Detection**	Frequency of Exceedance***
Methylene Chloride	-		-	-	-	-	0.30	b	9.00E-03	3.00E-02	10/16	0/10
Benzene	0.052	o	2.70E+00	5.19E+01	1/9	1/1	-		-	-	-	-
Toluene	0.79	o	3.40E+01	4.30E+01	1/9	1/1	-		-	-	-	-
Styrene	-		2.70E+01	-	1/9	-	-		-	-	-	-
Phenol	0.42	b	1.80E+02	4.29E+02	1/9	1/1	0.10	b	4.40E+00	4.40E+01	4/16	4/4
2-Methyl Phenol	0.063	b	1.40E+02	2.22E+03	4/9	4/4	0.10	b	1.10E+00	1.10E+01	4/16	2/4
4-Methyl Phenol	0.67	b	3.30E+02	4.93E+02	5/9	5/5	0.10	b	4.30E+00	4.30E+01	5/16	5/5
2,4-Dimethylphenol	0.029	b	1.60E+02	5.52E+03	3/9	3/3	0.10	b	2.30E+00	2.30E+01	4/16	3/4
Naphthalene	0.16	b	3.70E+04	2.31E+05	9/9	9/9	0.10	b	5.00E+02	5.00E+03	6/16	5/6
2-Methylnaphthalene	0.07	b	5.20E+03	7.43E+04	6/9	6/6	0.10	b	1.60E+01	1.60E+02	5/16	4/5
Acenaphthylene	0.044	b	9.00E+03	2.05E+05	9/9	9/9	0.10	b	1.20E+02	1.20E+03	8/16	6/8
Acenaphthene	0.016	b	9.30E+02	5.81E+04	6/9	6/6	0.10	b	4.20E+00	4.20E+01	7/16	5/7
Dibenzofuran	0.54	b	4.40E+03	8.15E+03	7/9	7/7	0.10	b	1.90E+01	1.90E+02	6/16	5/6
Fluorene	0.019	b	5.40E+03	2.84E+05	7/9	7/7	0.10	b	2.40E+01	2.40E+02	7/16	6/7
Phenanthrene	0.24	b	1.70E+04	7.08E+04	9/9	9/9	0.10	b	2.80E+02	2.80E+03	12/16	11/12
Anthracene	0.085	b	4.80E+03	5.63E+04	9/9	9/9	0.10	b	1.00E+02	1.00E+03	10/16	8/10
Fluoranthene	0.6	b	1.20E+04	2.00E+04	9/9	9/9	0.10	b	7.40E+02	7.40E+03	13/16	12/13
Pyrene	0.67	b	8.70E+03	1.31E+04	9/9	9/9	0.10	b	5.50E+02	5.50E+03	12/16	12/12
Benzo(a)anthracene	0.26	b	1.00E+02	3.83E+02	8/9	8/8	0.10	b	4.00E+02	4.00E+03	12/16	10/12
Chrysene	0.38	b	1.50E+02	3.91E+02	8/9	8/8	0.10	b	3.60E+02	3.60E+03	13/16	11/13
Bis(2-ethylhexyl)phthalate	-		-	-	-	-	1.15	o	6.10E-02	5.30E-02	1/16	0/1
Benzo(b)flouranthene	3.2	b	3.80E+03	1.19E+03	9/9	9/9	0.10	b	6.30E+02	6.30E+03	13/16	13/13
Benzo(k)fluoranthene	3.2	n	1.50E+03	4.69E+02	9/9	9/9	0.10	b	1.80E+02	1.80E+03	12/16	10/12
Benzo(a)pyrene	0.43	b	2.50E+03	5.81E+03	9/9	9/9	0.10	b	4.60E+02	4.60E+03	13/16	11/13
Indeno(1,2,3-cd)pyrene	0.60	b	3.40E+02	5.67E+02	9/9	9/9	0.10	b	3.30E+02	3.30E+03	12/16	10/12
Benzo(g,h,i)perylene	0.67	b	2.20E+02	3.28E+02	8/9	8/8	0.10	b	1.70E+02	1.70E+03	12/16	9/12
Dibenz(a,h)anthracene	0.06	b	2.80E+01	4.42E+02	1/9	1/1	0.10	b	1.00E+02	1.00E+03	8/16	6/8
Carbazole	-		3.20E+03	-	9/9	-	0.10	b	5.70E+01	5.70E+02	8/16	6/8
2-Butanone	0.27	o	1.60E-02	5.93E-02	1/9	0/1	-		-	-	-	-
Aroclor-1254	-		-	-	-	-	0.10	b	7.00E-02	7.00E-01	2/16	0/12

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Table 6 ***Sediment and Soil EEQs for On-Site Constituents of Potential Concern***
Crater Resources Site
Upper Merion Township, Pennsylvania

	Sediment						Soil					
Constituent	Screening Level (mg/Kg)		Maximum † Concentration (mg/Kg)	EEQ*	Frequency of Detection**	Frequency of Exceedance***	Screening Level (mg/Kg)		Maxiumum † Concentration (mg/Kg)	EEQ*	Frequency of Detection**	Frequency of Exceedance***
Cyanide(total)	0.10	o	5.28E+03	5.28E+04	9/9	9/9	0.005	b	1.75E+02	3.50E+04	6/16	6/6
Aluminum	-		1.31E+04	-	9/9	-	1	b	2.67E+04	2.67E+04	16/16	16/16
Antimony	2	n	1.20E+00	6.00E-01	1/9	0/1	0.48	b	1.80E+00	3.75E+00	1/16	1/1
Arsenic (total)	8.20	b	1.42E+02	1.73E+01	9/9	6/9	328	b	3.02E+02	9.21E-01	15/16	0/15
Barium	-		1.05E+02	-	9/9	-	440	b	2.87E+02	6.52E-01	16/16	0/16
Beryllium	-		5.60E+00	-	1/9	-	0.02	b	4.50E+00	2.25E+02	8/16	8/8
Cadmium	-		-	-	-	-	2.5	b	2.60E+00	1.04E+00	2/16	1/2
Calcium	-		1.75E+05	-	9/9	-	-		1.33E+05	-	16/16	-
Chromium (total)	0.01	b	2.09E+01	2.09E+03	9/9	9/9	0.005	b	3.31E+02	6.62E+04	16/16	16/16
Cobalt	-		3.79E+01	-	9/9	-	100	b	4.58E+01	4.58E-01	16/16	0/16
Copper	34	b	1.37E+02	4.03E+00	9/9	9/9	15	b	1.08E+02	7.20E+00	16/16	16/16
Iron	120	b	5.02E+04	4.18E+02	9/9	9/9	12	b	1.13E+05	9.42E+03	16/16	16/16
Lead	46.7	b	1.91E+02	4.09E+00	9/9	9/9	0.01	b	3.33E+02	3.33E+04	16/16	16/16
Magnesium	-		7.62E+03	-	9/9	-	-		2.24E+04	-	16/16	-
Manganese	460	o	7.74E+02	1.68E+00	9/9	6/9	330	b	6.20E+03	1.88E+01	16/16	14/16
Mercury	0.15	b	2.33E+01	1.55E+02	9/9	9/9	0.06	b	2.25E+01	3.88E+02	7/16	7/7
Nickel	20.9	b	7.67E+01	3.67E+00	9/9	9/9	2.00	b	6.75E+01	3.38E+01	16/16	16/16
Potassium	-		2.00E+03	-	6/9	-	-		1.70E+03	-	15/16	-
Selenium	0.92	n	1.05E+02	1.14E+02	9/9	9/9	1.8	b	1.09E+02	6.06E+01	6/16	6/6
Vanadium	-		2.11E+01	-	7/9	-	0.50	b	7.05E+01	1.41E+02	16/16	16/16
Zinc	150	b	5.37E+02	3.58E+00	9/9	9/9	10	b	1.15E+03	1.15E+02	16/16	16/16

b = USEPA Region III BTAG Screening Level (0.1 mg/kg used as a default soil screening level when a constituent-specific value was not available).
n = NOAA Screening Guideline.
o = Oak Ridge National Laboratory: Screening Benchmarks for Ecological Risk Assessment.

† = Maximum concentration is based on samples collected by ERM in April and May 1997.
* = Ecological Effects Quotient: maximum site concentration/screening level.
** = "6/9" represents 6 positive detections out of 9 samples in which the consitituent was analyzed.
*** = "6/9" represents 6 exceedances of the screening levels out of 9 positive detections.

Table 7 ***EEQs for On-Site Surface Water Constituents of Potential Concern***
Crater Resources Site
Upper Merion Township, Pennsylvania

Constituent	Screening Level (µg/L)		Surface Water Maximum † Concentration (µg/L)	EEQ*	Frequency of Detection**	Frequency of Exceedance***
2-Methylnaphthalene	300	n	2	6.67E-03	1/3	0/1
Anthracene	0.1	b	1	1.00E+01	1/3	1/1
Carbon Disulfide	2	b	0.88	4.40E-01	1/5	0/1
Cyanide(total)	5.2	b	1940	3.73E+02	3/3	3/3
Barium (dissolved)	4	o	91.1	2.28E+01	3/3	3/3
Calcium (dissolved)	116,000	o	85,200	7.34E-01	3/3	0/3
Copper (dissolved)	12	o	12.3	1.03E+00	3/3	1/3
Iron (dissolved)	320	b	989	3.09E+00	3/3	1/3
Magnesium (dissolved)	82,000	o	9140	1.11E-01	3/3	0/3
Manganese (dissolved)	14,500	b	228	1.57E-02	2/3	0/3
Potassium (dissolved)	53,000	o	1650	3.11E-02	3/3	0/3
Selenium (dissolved)	5	b	30.8	6.16E+00	3/3	3/3
Sodium (dissolved)	680,000	o	3400	5.00E-03	2/3	0/2
Zinc (dissolved)	30	b	78.9	2.63E+00	3/3	3/3

b = USEPA Region III BTAG Screening Level.
n = NOAA Screening Guideline.
o = Oak Ridge National Laboratory: Screening Benchmarks for Ecological Risk Assessment.

† = Maximum concentration is based on samples collected by ERM in April and May 1997.
* = Ecological Effects Quotient: maximum site concentration/screening level.
** = "2/3" represents 2 positive detections out of 3 samples in which the consitituent was analyzed.
*** = "0/2" represents 0 exceedances of the screening levels out of 2 positive detections.

Table 8 — ***Potential Constituents of Concern in Soil Samples***
Crater Resources Site
Upper Merion Township, Pennsylvania

	EEQ 1 - 9	EEQ 10 - 100	EEQ > 100
Phenol		4.40E+01	
2-Methyl Phenol		1.10E+01	
4-Methyl Phenol		4.30E+01	
2,4-Dimethylphenol		2.30E+01	
Naphthalene			5.00E+03
2-Methylnaphthalene			1.60E+02
Acenaphthylene			1.20E+03
Acenaphthene		4.20E+01	
Dibenzofuran			1.90E+02
Fluorene			2.40E+02
Phenanthrene			2.80E+03
Anthracene			1.00E+03
Fluoranthene			7.40E+03
Pyrene			5.50E+03
Chrysene			3.60E+03
Benzo(a)anthracene			4.00E+03
Benzo(b)fluoranthene			6.30E+03
Benzo(k)fluoranthene			1.80E+03
Benzo(a)pyrene			4.60E+03
Indeno(1,2,3-cd)pyrene			3.30E+03
Benzo(g,h,i)perylene			1.70E+03
Dibenz(a,h)anthracene			1.00E+03
Carbazole			5.70E+02
Cyanide(total)			3.50E+04
Aluminum			2.67E+04
Antimony	3.75E+00		
Beryllium			2.25E+02
Cadmium	1.04E+00		
Chromium			6.62E+04
Copper	7.20E+00		
Iron			9.42E+03
Lead			3.33E+04
Manganese		1.88E+01	
Mercury			3.88E+02
Nickel		3.38E+01	
Selenium		6.06E+01	
Vanadium			1.41E+02
Zinc			1.15E+02

Table 9 — *Potential Constituents of Concern in Sediments and Surface Water*
Crater Resources Site
Upper Merion Township, Pennsylvania

	EEQ 1 - 9	EEQ 10 - 99	EEQ > 100
Sediment Constituents			
Benzene		5.19E+01	
Toluene		4.30E+01	
Phenol			4.29E+02
2-Methyl Phenol			2.22E+03
4-Methyl Phenol			4.93E+02
2,4-Dimethylphenol			5.52E+03
Naphthalene			2.31E+05
2-Methylnaphthalene			7.43E+04
Acenaphthylene			2.05E+05
Acenaphthene			5.81E+04
Dibenzofuran			8.15E+03
Fluorene			2.84E+05
Phenanthrene			7.08E+04
Anthracene			5.63E+04
Fluoranthene			2.00E+04
Pyrene			1.31E+04
Benzo(a)anthracene			3.83E+02
Chrysene			3.91E+02
Benzo(b)fluoranthene			1.19E+03
Benzo(k)fluoranthene			4.69E+02
Benzo(a)pyrene			5.81E+03
Indeno(1,2,3-cd)pyrene			5.67E+02
Benzo(g,h,i)perylene			3.28E+02
Dibenz(a,h)anthracene			4.42E+02
Cyanide (total)			5.28E+04
Arsenic		1.73E+01	
Chromium			2.09E+03
Copper	4.03E+00		
Iron			4.18E+02
Lead	4.09E+00		
Manganese	1.68E+00		
Mercury			1.55E+02
Nickel	3.67E+00		
Selenium			1.14E+02
Zinc	3.58E+00		
Surface Water Constituents			
Anthracene		1.00E+01	
Cyanide (total)			3.73E+02
Barium (dissolved)		2.88E+01	
Copper (dissolved)	1.03E+00		
Iron (dissolved)	3.09E+00		
Selenium (dissolved)	6.16E+00		
Zinc (dissolved)	2.63E+00		

Table 10
Crater Resources Superfund Site
Estimated Cost of Alternatives

Alternative	Capital Cost	Annual Operation and Maintenance Cost	Total Present Worth Cost
SW-1: No Action	$ 0	$ 0	$ 0
SW-2: Institutional Controls	$ 145,000	$ 2,000	$ 230,000
SW-3: WAL Pipeline Investigation	—	—	$ 148,000
S-3: Soil Cover	$ 5,295,000	$ 9,900	$ 5,407,000
S-4: Low Permeability Cap	$ 7,353,000	$ 11,900	$ 7,501,000
S-4A: Quarry 3 Sediment Removal, Low Permeability Cap	$ 9,064,000	$ 11,900	$ 9,211,000
S-4B: Quarry 3 Sediment Stabilization, Low Permeability Cap	$ 10,342,000	$ 11,900	$ 10,489,000
S-5: Quarry 3 Removal, Low-Permeability Cap	$ 8,855,000	$ 11,900	$ 9,002,000
S-6: Complete Removal	$ 69,103,000	$ 0	$ 69,103,000
S-7: Stabilization	$ 79,873,000	$ 9,900	$ 104,030,000
GW-3: Monitored Natural Attenuation	$ 50,000	$ 26,600	$ 600,000
GW-4: Perimeter Groundwater Recovery	$ 1,607,000	$ 64,800	$ 3,380,000
GW-5: Groundwater Recovery, Treatment, and Discharge	$ 2,184,000	$ 221,700	$ 7,270,000

Table 11

Alternative S-5: Quarry 3 Removal/Off-Site Disposal and Low-Permeability Capping
Present Worth Analysis

Year	Capital Cost	Annual Cost (1)	Total Year Cost	Annual Discount Rate at 7% (2)	Present Worth
0	$8,854,522		$8,854,522	1.000	$8,854,522
1		$11,900	$11,900	0.935	$11,127
2		$11,900	$11,900	0.873	$10,389
3		$11,900	$11,900	0.816	$9,710
4		$11,900	$11,900	0.763	$9,080
5		$11,900	$11,900	0.713	$8,485
6		$11,900	$11,900	0.666	$7,925
7		$11,900	$11,900	0.623	$7,414
8		$11,900	$11,900	0.582	$6,926
9		$11,900	$11,900	0.544	$6,474
10		$11,900	$11,900	0.508	$6,045
11		$11,900	$11,900	0.475	$5,653
12		$11,900	$11,900	0.444	$5,284
13		$11,900	$11,900	0.415	$4,939
14		$11,900	$11,900	0.388	$4,617
15		$11,900	$11,900	0.362	$4,308
16		$11,900	$11,900	0.339	$4,034
17		$11,900	$11,900	0.317	$3,772
18		$11,900	$11,900	0.296	$3,522
19		$11,900	$11,900	0.277	$3,296
20		$11,900	$11,900	0.258	$3,070
21		$11,900	$11,900	0.242	$2,880
22		$11,900	$11,900	0.226	$2,689
23		$11,900	$11,900	0.211	$2,511
24		$11,900	$11,900	0.197	$2,344
25		$11,900	$11,900	0.184	$2,190
26		$11,900	$11,900	0.172	$2,047
27		$11,900	$11,900	0.161	$1,916
28		$11,900	$11,900	0.150	$1,785
29		$11,900	$11,900	0.141	$1,678
30		$11,900	$11,900	0.131	$1,559
				TOTAL PRESENT WORTH	**$9,002,190**

Note:
(1) ERM's Annual O&M Cost
(2) ERM's Discount Rate at 5% vs TtNUS's Discount Rate at 7% (EPA OSWER #9355.3-20)

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Table 11

Alternative S-5: Quarry 3 Removal/Off-Site Disposal and Low-Permeability Capping

Capital Cost

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Total Cost Subcontract	Total Cost Material	Total Cost Labor	Total Cost Equipment	Total Direct Cost	Note
1 PROJECT DOCUMENTS/INSTITUTIONAL CONTROLS												
1.1 Prepare Documents & Plans including Permits	500	hr			$40.00		$0	$0	$20,000	$0	$20,000	(1)
1.2 Property Use Restrictions	750	hr			$40.00		$0	$0	$30,000	$0	$30,000	(1)
2 SITE PREPARATION												
2.1 E & S Controls (includes retention basin)	1	ls		$12,500.00	$20,000.00	$17,500.00	$0	$12,500	$20,000	$17,500	$50,000	(2)
2.2 Clear & Grub Area for Soil Cover	10	ac			$1,125.00	$1,100.00	$0	$0	$11,250	$11,000	$22,250	(3)
2.3 Site Grading for Stormwater Runoff	67,760	sy			$0.20	$0.26	$0	$0	$13,552	$17,618	$31,170	(3)
2.4 Construction of Roadway	1	ls		$6,250.00	$10,000.00	$8,750.00	$0	$6,250	$10,000	$8,750	$25,000	(2)
3 DEWATERING, TREATMENT & DISPOSAL OF SURFACE WATER												
3.1 Dewatering Ponds 1, 2 & 3	4,600,000	gal			$0.03	$0.02	$0	$0	$138,000	$92,000	$230,000	(2)
3.2 Hauling Surface Water, 10 miles	4,600,000	gal			$0.04	$0.03	$0	$0	$161,000	$138,000	$299,000	(2)
4 PARTIAL REMOVAL AND ASSOCIATED BACKFILL												
4.1 Excavate Plateau Area	11,980	cy			$2.66	$3.28	$0	$0	$31,867	$39,294	$71,161	(3)
4.2 Surface Soil Removal - Remaining Areas	6,065	cy			$2.66	$3.28	$0	$0	$16,133	$19,893	$36,026	(3)
4.3 Sediment Removal	10,110	cy			$5.46	$6.58	$0	$0	$55,201	$66,524	$121,724	(3)
4.4 General Fill - Delivered (backfill to original grade)	42,233	ton		$8.00			$0	$337,864	$0	$0	$337,864	(4)
4.5 General Fill - Spread with Dozer	28,155	cy			$0.53	$1.85	$0	$0	$14,922	$52,087	$67,009	(3)
4.6 General Fill - Compaction	28,155	cy			$0.21	$0.62	$0	$0	$5,913	$17,456	$23,369	(3)
5 OFF-SITE REMOVAL AND DISPOSAL OF CONTAMINATED SOILS												
5.1 Containment Area for Processing	1	ls		$5,000.00	$5,000.00	$5,000.00	$0	$5,000	$5,000	$5,000	$15,000	(2)
5.2 Soil/Sediment Loading	28,155	cy			$0.20	$0.25	$0	$0	$5,631	$7,039	$12,670	(3)
5.3 Transport & Disposal for Contaminated Soils	42,233	ton	$46.00				$1,942,718	$0	$0	$0	$1,942,718	(4)
6 MULTI-MEDIA CAP AT QUARRY 3 WITH TOPSOIL COVER												
6.1 Soil Excavation & Relocation (300' haul)	10,430	cy			$2.66	$3.28	$0	$0	$27,744	$34,210	$61,954	(3)
6.2 General Fill - Delivered	15,645	ton		$8.00			$0	$125,160	$0	$0	$125,160	(4)
6.3 General Fill - Spread with Dozer	10,430	cy			$0.53	$1.85	$0	$0	$5,528	$19,296	$24,823	(3)
6.4 General Fill - Compaction	10,430	cy			$0.21	$0.62	$0	$0	$2,190	$6,467	$8,657	(3)
6.5 Soil Cover, 6"	2,712	cy		$5.06	$0.86	$1.98	$0	$13,723	$2,332	$5,370	$21,425	(5)
6.6 Topsoil - Loading	2,712	cy		$13.10	$0.52	$0.77	$0	$35,527	$1,410	$2,088	$39,026	(3)
6.7 Topsoil - Hauling (10 mile)	2,712	cy			$1.66	$5.10	$0	$0	$4,502	$13,831	$18,333	(3)
6.8 Topsoil, 6" - Spread with Dozer	2,712	cy			$0.53	$1.85	$0	$0	$1,437	$5,017	$6,455	(3)
6.9 Seed & Mulch	146	msf		$46.00	$7.40	$7.85	$0	$6,736	$1,084	$1,149	$8,969	(3)
6.10 Drainage Trench	2,500	lf			$1.42	$1.02	$0	$0	$3,550	$2,550	$6,100	(3)
6.11 Channel Lining (riprap)	75	cy		$17.05	$7.05	$8.50	$0	$1,279	$529	$638	$2,445	(3)

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Table 11

Alternative S-5: Quarry 3 Removal/Off-Site Disposal and Low-Permeability Capping

Capital Cost

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Total Cost Subcontract	Total Cost Material	Total Cost Labor	Total Cost Equipment	Total Direct Cost	Note
7 MULTI-MEDIA CAP WITH ASPHALT COVER REMAINING AREA												
7.1 General Fill - Delivered	30,900	ton		$8.00			$0	$247,200	$0	$0	$247,200	(4)
7.2 General Fill - Spread with Dozer	20,600	cy			$0.53	$1.85	$0	$0	$10,918	$38,110	$49,028	(3)
7.3 General Fill - Compaction	20,600	cy			$0.21	$0.62	$0	$0	$4,326	$12,772	$17,098	(3)
7.4 Low Perm Clay	11,044	cy		$5.99	$2.56	$4.65	$0	$66,154	$28,273	$51,355	$145,781	(5)
7.5 HDPE liner, 40 mil	298,179	sf		$0.26	$0.77	$0.17	$0	$77,527	$229,598	$50,690	$357,815	(5)
7.6 Sand Drainage Layer	3,644	cy		$7.83	$0.86	$1.76	$0	$28,533	$3,134	$6,413	$38,080	(5)
7.7 Aggregate Sub-base, 6"	33,133	sy		$5.95	$0.33	$0.63	$0	$197,141	$10,934	$20,874	$228,949	(3)
7.8 Binder Course, 2"	33,131	sy		$2.49	$0.34	$0.28	$0	$82,496	$11,265	$9,277	$103,037	(3)
7.9 Wearing Course, 1 1/2"	33,131	sy		$2.23	$0.31	$0.26	$0	$73,882	$10,271	$8,614	$92,767	(3)
7.10 Drainage Improvements	1	ls		$6,250.00	$10,000.00	$8,750.00	$0	$6,250	$10,000	$8,750	$25,000	(2)
Subtotal							$1,942,718	$1,323,221	$907,492	$789,631	$4,963,062	
Local Area Adjustments							100.0%	105.0%	95.0%	95.0%		(3)
Subtotal							$1,942,718	$1,389,382	$862,117	$750,150	$4,944,367	
Burden on Labor Cost @ 30%									$258,635		$258,635	
G & A on Labor Cost @ 10%									$86,212		$86,212	
G & A on Material Cost @ 10%								$138,938			$138,938	
Tax on Material Cost @ 6%								$83,363			$83,363	
G & A on Subcontract Cost @ 5%							$97,136				$97,136	
Total Direct Cost							$2,039,854	$1,611,683	$1,206,964	$750,150	$5,608,650	
Indirects on Total Direct Cost @ 25%											$1,402,163	
Profit on Total Direct Cost @ 5%											$280,433	
Total Field Cost											$7,291,246	
Contingency on Total Field Cost @ 20%											$1,458,249	
Engineering Cost @ 2%	(Total Field Cost minus Subcontractor's Total Direct Cost)										$105,028	
TOTAL COST											$8,854,522	

Table 11

Alternative S-5: Quarry 3 Removal/Off-Site Disposal and Low-Permeability Capping

Capital Cost

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Total Cost Subcontract	Total Cost Material	Total Cost Labor	Total Cost Equipment	Total Direct Cost	Note

NOTES: Source of costs
- (1) Past Costing Experience
- (2) ERM Cost
- (3) Means 2000 Cost
- (4) Vender Quote
- (5) ECHOS 2000 Cost

Assume density of general fill equal to 1.5 tons per cubic yard

Disposal cost of soil/sediments assumes materials are non-hazardous with disposal at a local Subtitle D Landfill.

Indirects include:

Construction Management, Legal, Travel, Medical, Supplies, Data Process, Bond Premium Insurance, Security, Testing & Analysis, Maintenance, Timekeeper, Photos, Pre and Post Documents (as-builts, reports), Pollution Insurance, Normal Trash Disposal, and Site Clean up.

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Table 12 Soil and Sediment Cleanup Standards (mg/kg) (Risk-based cleanup levels except where noted)						
Contaminant	**Quarry 3 Surface**	**Quarry 3 Sediment**	**Quarry 3 Sub-surface**	**SS-1 and 2**	**SS-3**	**Yellow Parcel Pipeline**
Benzo(a)anthracene	3.59	110[2]	-	-	-	4.48
Benzo(b)fluoranthene	5.65	110[2]	-	-	-	8.55
Benzo(a)pyrene	4.13	11[2]	11[2]	-	4.55	5.23
Dibenz(a,h)anthracene	0.897	-	4.48	-	-	0.177
Dibenzofuran	-	.66	-	-	-	3.180
Indeno(1,2,3-c,d)pyrene	2.96	-	-	-	-	1.26
2-Methylnaphthalene	-	-	16	-	-	-
Naphthalene	-	0.2[1]	0.20[1]	-	-	-
Aluminum	13,800	-	-	986	-	14,800
Arsenic	0.2[1]	-	0.2[1]	-	6.06	0.586
Chromium	-	-	-	-	-	0.525
Iron	40[1]	-	-	190,000[2]	190,000[2]	190,000[2]
Manganese	-	-	200	197	212	-
Mercury	11.6	-	13	-	-	-

[1] Based on Soil Screening Level
[2] Based on PADEP's Act 2 Standards

Table 13 Groundwater Cleanup Standards (µg/l) (Risk-based cleanup levels)		
Contaminant	**Center of Plume**	**Extent of Plume**
Acetone	95.9	24
Benzene	5	0.04
Chloroform	1	0.015
Dibenzofuran	12	0.86
2,4-Dimethylphenol	1.15	1
2-Methylphenol	12.5	1
4-Methylphenol	47.7	1
Naphthalene	5	1
Phenol	7,860	-
Cyanide	10	13
Arsenic	1	0.04
Barium	40	450
Beryllium	4	4
Cadmium	-	0.62
Chromium	8	12
Cobalt	-	22
Iron	250	2,300
Lead	15	15
Manganese	66.8	310
Mercury	-	0.004
Nickel	-	260
Selenium	0.4	0.006
Thallium	-	0.17
Vanadium	-	0.41
Zinc	-	170

TABLE 14
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS) AND TO BE CONSIDERED MATERIAL (TBCs) FOR THE CRATER RESOURCES SITE

ARAR or TBC		Legal Citation	Classification	Summary of Requirement	Further Detail Regarding ARARs in the Context of the Remedy
I. CHEMICAL SPECIFIC					
A. Water					
1.	Safe Drinking Water Act	42 U.S.C.§§300g-1			
a.	Maximum Contaminant Levels (MCLs)	40 C.F.R. §§141.11-12 and 141.61-62	Relevant and Appropriate	MCLs are enforceable standards for public drinking water supply systems which have at least 15 service connections or are used by at least 25 persons. These requirements are not directly applicable since ground water in the vicinity of the Site is not used as a private drinking water supply. However, under the circumstances of this Site, MCLs are relevant and appropriate requirements which were considered in establishing ground water cleanup levels.	The groundwater will meet these requirements. The ground water cleanup standards listed on Table 13 will meet or exceed the MCLs.
b.	Maximum Contaminant Level Goals (MCLGs)	40 C.F.R. §141.50-.51	Relevant and Appropriate	MCLGs are non-enforceable health goals for public water supplies which have at least 15 service connections or are used by 25 persons. Under the circumstances of this Site, MCLGs are relevant and appropriate requirements which were considered in establishing ground water cleanup levels.	The groundwater will meet these requirements. The ground water cleanup standards listed on Table 13 will meet or exceed the MCLGs.
2.	Pennsylvania Water Quality Standards	25 PA Code Chapters 93.4a, 93.5-93.7, and 93.8a	Relevant and Appropriate	These are guidelines established pursuant to Section 304 of the Clean Water Act that set the concentrations of pollutants that are allowable at levels which preserve human health based on water and fish ingestion and to preserve aquatic life. Ambient water quality criteria may be relevant and appropriate to CERCLA cleanups based on the uses of a water body.	These requirements will be an ARAR if the discharge associated with Alternative GW-3, if any, is to an on-site surface water. Such on-site discharge would meet the guidelines established for protection of aquatic life.
3.	Integrated Risk Information System (IRIS)	EPA Office of Research and Development	To Be Considered	IRIS is an EPA data base containing up-to-date health risk and EPA regulatory information for numerous chemicals. IRIS is the preferred source of toxicity information as it contains only those reference doses (RfDs) and cancer slope factors that have been verified by the RfD or Carcinogen Risk Assessment Verification Endeavor Workgroups.	These non-enforceable toxicity values have been considered while developing site-specific cleanup standards for each remedial alternative.

TABLE 14
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS) AND TO BE CONSIDERED MATERIAL (TBCs) FOR THE CRATER RESOURCES SITE

ARAR or TBC	Legal Citation	Classification	Summary of Requirement	Further Detail Regarding ARARs in the Context of the Remedy
B. Soil				
1. Risk Assessment Guidance for Superfund - Volume I Human Health Manual Part A, December 1989	EPA Office of Emergency and Remedial Response EPA/540/1-89/002	To be Considered	EPA guidance for calculating baseline human health risk and establishing risk-based performance standards for Superfund clean-ups. Section 7.4 sets forth method for identifying appropriate toxicity values for contaminants of concern.	There are currently no ARARs establishing acceptable concentrations for contaminants in soil or sediment at the Site. This guidance document was considered when establishing risk based cleanup standards.
2. Pennsylvania Act 2 Program - Statewide Health Standards for soils	PA Code Chapter 250.305	Applicable	This regulation establishes requirements for voluntary cleanup activities.	Where Act 2's statewide health standards for soils provide more stringent requirements than the risk-based cleanup standards for the site, EPA has incorporated these more stringent requirements as cleanup standards in Table 12.
II. LOCATION SPECIFIC				
1. Pennsylvania Wetlands Regulations	25 PA Code Chapter 105.18a	Applicable	Protects wetlands of the Commonwealth from dredging, filling, removal, or other alteration and requires Commonwealth oversight and approval.	The substantive requirements of these regulations shall be applicable if construction of the cap, or discharge to surface water impacts regulated wetlands, if any.
2. Preservation of Historical & Archaeological Data Act	16 U.S.C. § 469	Applicable	Requires actions to avoid potential loss or destruction of significant scientific, historical, or archaeological data.	Actions shall be taken to mitigate any adverse effects on identified off-site historic resources that might result from implementation of the remedial action.
III. ACTION SPECIFIC				
A. Water				
1. Clean Water Act (CWA); Pennsylvania National Pollutant Discharge Elimination System Requirements;	40 CFR Part 125.3 40 CFR Part 122.44-.45 25 PA Code Chapters 95.1 - 95.3	Applicable	Establishes substantive requirements and limits for discharges to waters of Pennsylvania and the United States.	These requirements will be an ARAR if the discharge associated with Alternative GW-3, if at all, is to an on-site surface water source. Such on-site discharge would comply with these discharge standards.
2. Storm Water Management Act	32 P.S.§ 680.13	Applicable	Requires implementation of stormwater control measures to prevent injury to health, safety, or property.	Stormwater shall be managed to control stormwater during construction of the remedy.

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TABLE 14
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS) AND TO BE CONSIDERED MATERIAL (TBCs) FOR THE CRATER RESOURCES SITE

	ARAR or TBC	Legal Citation	Classification	Summary of Requirement	Further Detail Regarding ARARs in the Context of the Remedy
3.	Erosion and Sediment Control	25 PA Code 102.4(b)(1), 102.11, 102.22	Applicable	Identifies erosion and sediment control requirements and criteria for activities involving land clearing, grading and other earth disturbances and establishes erosion and sediment control criteria.	These regulations apply to construction activities at the Site which disturb the ground surface, including clearing, grading, excavation and cap installation.
4.	Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites, April 1999	OSWER Directive 9200.4-17R	To Be Considered	This policy provides guidance for evaluating and approving monitored natural attenuation remedies.	This policy shall be considered during the implementation of the monitored natural attenuation remedy.
B. Air					
1.	Air Emission Standards for Process Vents	40 C.F.R. Part 264.1030 through 264.1034 and 40 CFR Part 264.1053 - 264.1063	Relevant and Appropriate	Establishes requirements for process vents and equipment leaks.	Emissions due to potential leaks from the contingent treatment plant would comply with this requirement.
2.	Federal Regulations Governing Hazardous Air Pollutants (NESHAPS)	40 CFR 61.242-1 through 61.244	Relevant and Appropriate	Requires emissions of Hazardous Air Pollutants (HAPs) from new and existing sources to be quantified; establishes ambient air quality standards and emissions limitations for HAP emissions from new sources.	The excavation of the PAH - contaminated materials in Quarry 3 will comply with the HAP Standards.
3.	Control of Air Emissions from Air Strippers at Superfund Groundwater Sites, June 15, 1989	OSWER Directive 9355.0-28	To Be Considered	This policy relates to the selection of control for air strippers at ground water sites according to the air quality status of the area of the site (i.e., whether it is an attainment or non-attainment area).	This policy shall be considered in determining if air emission controls are necessary for the air stripper. Sources most in need of the controls are those with emissions rates in excess of 3 lbs./hour or 15 lbs./day or a potential rate of 10 tons/year of total VOCs.
4.	Fugitive Air Emissions	25 PA Code Chapter 123.1 - 123.2 40 CFR § 50.6 - 50.7	Applicable	Establishes the fugitive dust regulation for particulate matter.	The capping and excavation activities will comply with these regulations.
5.	Malodorous Air Emissions	25 PA Code 123.31	Applicable	Prohibits malodors detectable beyond the site property line.	Emissions from the excavation and construction will comply with this requirement.
6.	Visible Air Emissions	25 PA Code 123.41	Applicable	Establishes opacity limits for visible air emissions.	Emissions from the excavation and construction will comply with this requirement.
7.	Pennsylvania Standards for New Stationary Sources	25 PA Code Chapters 121.7 and 127.1	Applicable	Requires all new air emission sources to achieve minimum attainable emissions using best available technology.	Emissions for the contingent groundwater treatment plant would comply with this requirement.

TABLE 14
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS) AND TO BE CONSIDERED MATERIAL (TBCs) FOR THE CRATER RESOURCES SITE

ARAR or TBC	Legal Citation	Classification	Summary of Requirement	Further Detail Regarding ARARs in the Context of the Remedy
C. Solid Waste				
1. Residual Waste Landfill	25 PA Code 288.234, 288.236 and 288.237, 288.241-244	Relevant and Appropriate	Establishes minimum requirements for closure of residual waste landfills in the Commonwealth, including minimum cap specifications.	The specifications of the cap shall, at a minimum, comply with the Commonwealth of PA closure requirements.
D. Hazardous Waste				
1. Standards applicable to Generators.	25 PA Code 75.262 or 25 PA Code 262a	Applicable	Hazardous waste determination requirements applicable to generators who treat, store, or dispose of hazardous waste.	Any treatment, storage or disposal of soils that are considered hazardous waste shall comply with the more stringent substantive requirements of either 25 PA Code 75.262 or 25 PA Code 262a.[1]
2. Standards for Owners and Operators of Hazardous Waste TSDs	25 PA Code 75.264 or 25 PA Code 264a (Subchapters I, J, and L)	Applicable	Establishes standards for storing hazardous waste on-site.	In the event that excavated soil or sediments are hazardous waste, the material shall be stored in accordance with the more stringent substantive requirements of either 25 Pa. Code 75.264 or 25 Pa. Code 264a (Subchapters I, J, and L) concerning the manner of storage.[2]
E. Residual Waste				
1. Residual Waste Regulations	25 PA Code 299.101-.133 25 PA Code 299.211-215	Applicable	Establishes the criteria for storing residual waste.	In the event the soils and sediments are not considered hazardous waste, the substantive requirements for storage and transportation of residual waste apply.

[1]25 PA Code 75.262 is part of Pennsylvania's EPA-authorized hazardous waste program. 25 PA Code 262a represents Pennsylvania's new regulation, which is pending authorization from EPA, and will supercede 25 PA Code 75.262.

[2]25 PA Code 75.264 is part of Pennsylvania's EPA-authorized hazardous waste program. 25 PA Code 262a represents Pennsylvania's new regulation, which is pending authorization from EPA, and will supercede 25 PA Code 75.264.